REVIEW.

Art. X.—*Leçons sur le Sang, et les Alterations de ce liquide dans les Maladies graves.* Par Prof. Magendie. Bruxelles, 1839.

Course of Lectures on the Blood, and on the Changes which it undergoes during Disease. Delivered at the College of France in 1837–8. By M. Magendie. London, 1839.

Notwithstanding the blood has been a subject of curious speculation from the most remote period, our knowledge of its physiology and pathology still remains extremely defective. On many points connected with these important subjects, we are, in fact, in entire ignorance. Upon even the composition and physical properties of the blood, and the forces by which its circulation throughout the organism is effected, discordant opinions are entertained by the most distinguished contemporary physiologists; while, of the modifications it undergoes during health, its various morbid conditions, and their influence in the production or modification of diseased phenomena, we know absolutely nothing. Every thing that has been heretofore advanced in relation to these particulars, can be viewed in no other light than specious hypotheses, unsupported by facts.

It is evident, therefore, that few subjects present a more extensive field for investigation, or in relation to which may be anticipated results of greater importance in a physiological as well as pathological and therapeutical point of view, from a well devised and cautiously performed series of experiments and observations. Hence the lectures on the blood by M. Magendie, possess a peculiar interest; more especially as the statements and opinions contained in them, are professedly deductions from careful and repeated experiments and observations, many of them of a novel and very striking character, performed by the lecturer in the presence of his class.

M. Magendie has studied the blood, to use his own words, not only in chemical apparatuses, but in the living animal, and in the human subject labouring under disease; every question connected with it is examined by him in its physical, chemical, mechanical and vital bearing; life, as he remarks, being the result of these different modes of action.

By the experiments and observations of the lecturer, many particulars in relation to the properties of the blood, and the forces by which it is circulated, that have heretofore been subjects of doubt or of dispute, are fully established, and several new facts in its physiology elicited. His experiments and observations upon the effects of various abnormal conditions of the blood, present, likewise, many important facts for the consideration of the pathologist.

Notwithstanding M. Magendie declares, in his second lecture, that he does "not believe that disease is ever developed without some modification or other existing in the blood;" yet he repeatedly denies any intention of

ascribing to morbid changes in the blood every diseased condition of the organism.

The whole of his illustrations and reasoning, and many of his experiments, prove, however, that he considers a morbid state of the blood to be, if not the invariable cause of the diseased states of the organism, at least the chief agent in the production of the several organic lesions which take place in the course, or towards the termination of disease. The various local affections discovered after death, heretofore ascribed to inflammation and its consequences, M. Magendie ascribes, in fact, in every instance, to the physical effects resulting from a change in the composition of the blood, from the suspension of its circulation in the capillaries of the part, and from its infiltration into the surrounding tissues. He would appear to consider, indeed, a large proportion of the phenomena of health and disease to be the result rather of physical than of vital forces.

"My experiments," he remarks, (Lecture 2d,) "have proved that various actions, habitually called the effects of *vitality*, are purely *physical*."

He pronounces (Lecture 14th) the "unvarying attempt to discover in the vitality of our tissues, the cause of the majority of the disorders to which they are liable," a "most serious error."

In another part, he refers our defective acquaintance with the physiology of the animal organism to our ascribing many phenomena to presumed vital forces, which are in fact of a purely physical character; which, to a certain extent, is unquestionably true.

"Turn where they will," he remarks, (Lecture 5th,) "our medical men find nothing but vitality, just as if the organisation of the frame were not quite as worthy of our admiration, regulated by physical laws, as by a jumble of pretended vital properties. They will not allow a membrane to be a membrane; they refuse to believe that when a membrane is brought in contact with liquids, either imbibition or exhibition follows. No, that would be too simple; they must have exhalent vessels, and absorbent vessels, and they must endow these vessels with intelligence, and make this intelligence decide on the fitness of this or that substance to enter their cavity."

That the changes which occur in the blood, in various states of disease, are more decided and of far more importance in a pathological and therapeutical point of view, than they are usually esteemed by physicians of the present day, our own experience has taught us to believe. We view, therefore, the experiments of M. Magendie upon the effects resulting from various abnormal conditions of the blood, artificially produced, as in the highest degree interesting. With many of the conclusions he would appear to draw from these experiments, we cannot, however, coincide.

To do full justice to the pathological views of the lecturer, and to show how far he is willing to admit a deterioration of the blood to act in the production of disease, we present the following extracts from his third lecture.

"I am far from maintaining that all diseases originate in altered conditions of the blood. Such an opinion would be grossly absurd. Our organs are liable to be influenced by a number of agents which directly modify, as it were, their texture. Thus, for example, intense cold causes the contraction of the pulmonary vesicles, and by this purely physical action, the circulation is retarded, and may be temporarily stopped. It is not necessary for me to enumerate the series of phenomena that ensues.

"On the other hand, if the temperature be too high, the capacity of the ves-

sels is increased, and not only is the circulation affected thereby, but the composition of the blood may be modified to such an extent as to produce affections analogous to those just alluded to. Here, then, are two phenomena, perfectly physical in their nature, to which a considerable number of local lesions are traceable.

"Hence, local diseases may originate either in an alteration of the blood, or of the tissues of the organs themselves. The distinction between these two sources of topical affections should never be lost sight of, especially in regulating the treatment.

"There are other causes of local disorders wholly distinct from those I have mentioned. Thus, the chemical injuries effected in the stomach by the concentrated acids, will never be confounded by any one in his senses, with disorders induced by a morbid condition of the blood, no more than will the mischief caused by the violent drastics that certain individuals have the signal effrontery to extol as sovereign balms for every variety of complaint.

"These cursory observations will suffice to show you that there certainly exist diseases brought on by a morbid condition of the fluids, as well as others by a primitive alteration of the solids; they will, besides, convince you that I am neither exclusively a humourist nor a solidist."

In endeavouring to present to our readers a summary of these lectures, we shall be obliged to confine ourselves to the leading facts embraced in them, and this without any attention to the order in which they occur. The minute description of the progress and result of varied experiments, performed in the view of the class, with which the lectures abound, and the frequent repetitions to which the plan pursued by M. Magendie in their delivery necessarily gives rise, prevent any regular analysis of the subjects embraced in each.

The circulation of the blood throughout every portion of the body is ascribed by M. Magendie to the force of the heart, aided by the elasticity of the arteries, the action of the muscles, and the respiratory movements. The supposed sorbent power of the venous radicles, the independent action of the capillaries, and the motive powers of the globules themselves, which have been described as so many powers concerned in effecting the circulation of the blood, he has shown to have no existence excepting in the imagination of certain modern physiologists. The arteries, capillaries, and veins, he has proved to be altogether passive organs, the blood in the one set of vessels being acted upon by the same forces as it is in the others.

M. Magendie's experiments on the circulation of the blood are rendered more exact and interesting by the employment of an instrument invented by M. Poiseuille, the hæmodynamometer.

"It has received its name from the purpose to which it is applied, namely, the measurement of the force that moves the blood (αιμα, *blood*, δυναμις, *force*, μετρεω, *a measure.*) It consists of a glass tube presenting a horizontal branch, a descending vertical branch, and an ascending branch; these are curved, so as to form a quarter of a circle and a semicircle, at two different points. A certain quantity of mercury is placed in the tube, and it is evident that when the instrument is in a vertical position, the upper surface of the mercury will be on the same level in both branches. But if the blood be allowed to enter into the horizontal branch by an orifice communicating with the interior of a vessel, it will press on the surface of the mercury; the metal will, therefore, be depressed to a certain point in the descending branch, and will rise to the same extent in the ascending branch. The degree of depression and elevation is estimated by two scales, graduated by millimetres, attached to the vertical branches of the instrument. When the apparatus is about to be used, the horizontal branch is

filled with a saturated solution of subcarbonate of soda, which M. P. found, after a variety of trials, the best material for preventing the coagulation of the blood. A small brass tube receives into a concavity the extremity of the horizontal branch of the glass tube, and is fixed to it with Spanish wax. At the other extremity of this little brass tube, is a screw, intended to pass into another brass tube, one extremity of which presents a cavity of the same form as the nut of the screw; the other is free, intended for introduction into the interior of the vessels, and provided with a prominent rim. As the slightest inclination in the instrument would cause a variation in the height of the columns of mercury, a leaden wire is adapted to it, to secure it in an accurately vertical position. When we wish to bring the instrument into communication with the blood, we lay bare an artery, seize it between the fingers, taking care first to pass a ligature round it, and make a longitudinal incision beyond the compressed point. The lips of the wound in the vessel are next laid hold of with a forceps, and separated from each other so as to render the orifice as circular as possible. The tube is then introduced, and the artery tied below the rim of the instrument. The moment we cease to compress the vessel between the fingers, the blood passes from it into the tube, mixes with the carbonate of soda, and so trasmits the force of its impulsion to the column of mercury."—Lecture 6th.

One of the most interesting facts established by this instrument, is the uniform amount of pressure exerted by the blood upon the coats of the arteries in every part of the body; those in the immediate vicinity of the heart being distended by an equal force with those the most remote from it. M. Poiseuille made the experiment on the carotid, and on the muscular branch of the thigh of a horse, and notwithstanding the very great dissimilarity in the diameter, and distance from the heart, of the two tubes, the displacement of the mercury was exactly the same in both.

"This equality of pressure throughout the entire arterial system is," observes M. Magendie, "an extremely important fact, in a practical point of view. It shows that if the practitioner desire to lessen the quantity of fluid in circulation, it is of little consequence what vessel he opens; for the equilibrium of pressure is simultaneously re-established in all the vascular tubes."—Lecture 6th.

"This law of the recovery of the equilibrium of pressure," he remarks in a subsequent lecture, (the 9th) "is of fundamental importance in the study of the circulation. Practitioners who are unacquainted with it, fancy, in many cases, that by following certain rules in the employment of bloodletting they shall obtain extraordinary advantages, but they sadly deceive themselves. When, for instance, they have a case of apoplexy to treat, they fix on the temporal artery in preference to any other vessel, whence to deplete the vascular system. As that vessel is the nearest to the seat of the lesion, argue these reasoners, it must hold the cerebral circulation more immediately under its dependence."

"If the circulation were formed of a series of rings, mutually independent of each other, we might rationally open one vessel rather than another, according to the site of the disorder we had to combat, but the chain formed by the arterial tubes is perfectly continuous throughout the frame. Whether you bleed from the temporal or the tibial artery, the effects will be mechanically the same in respect of the circulation of the brain. The preference given the former of these vessels is justified by its superficial position, which renders it easily accessible; but as regards the therapeutical influence of its division, it can lay claim to no real superiority. If you represent by five the diminution of pressure in the temporal, you must represent by five also that in the tibial artery." —*Ibid.*

Not only does this equality of pressure exist throughout the arteries of the same animal, but it is also similar in animals differing considerably in magnitude and in strength. M. Poiseuille found that the hæmodynamometer when applied to the arteries of a dog, rabbit or guinea pig, indicated the same amount

of pressure as when applied to those of the horse. So that a heart weighing one or more ounces, transmits the same amount of pressure to the walls of the vessels, as one weighing six or seven pounds.—Lecture 6th.

"These are," the lecturer remarks, "no doubt, most curious facts; still they are comprehensible, for the question of which they involve the answer, is not to calculate the total force of the heart, but the surface of the column of blood displaced."—*Ibid.*

The circumstances that modify the pressure of the blood, are, according to M. Magendie, referrible to two principal causes, the mass of liquid in movement, and the force of impulsion. We must also take most accurate note of the movement of respiration. M. Magendie found in his experiments, that the force with which the blood moves in the arteries, is diminished during inspiration, but augmented during expiration; and that during the action of coughing also, the movement of the blood is accelerated. Hence he remarks, the heart is "the constant agent of the circulation; but the respiratory movements exercise so powerful an influence in this way, that during deep expiration, the force that moves the arterial blood, becomes almost double as great as in the normal state."—Lecture 6th.

Aware that the amount of fluid contained within the blood vessels cannot be increased without the vessels suffering an augmented pressure, M. Magendie believed it possible to cause at will the elevation or descent of the column of mercury in the instrument, by adding to or subtracting from, the circulating fluid, given quantities of liquid. By drawing blood from the blood vessels, the amount of pressure was evidently diminished in proportion to the amount abstracted; but the reverse experiment, augmenting, namely, the amount of fluid in the veins, did not present the anticipated result; a quantity of tepid water was thrown into the jugular vein of a dog, but the instrument indicated, instead of an increase, a considerable diminution of pressure. In this experiment, M. Magendie observes,

"The volume of the blood was, no doubt, rendered more considerable than before, but the energy of the heart's contractility was diminished by the presence of the water. My injection had the same effect as the diluents used in practice, for the purpose of moderating the violence of fever; the augmentation of the aqueous part of the blood weakened the force of impulsion of the left ventricle, and the pressure, in consequence, became less than previously throughout the entire system."

Hence, he infers that, "the volume of liquid in the vessels does not contribute so much as the energy of the heart's contractions to the arterial pressure." Lect. 7.

On injecting an infusion of coffee into the jugular vein of the dog, which was the subject of the above experiment, a notable rise was produced in the column of mercury; on the subsequent injection of two drachms of brandy and water, the mercury was found to sink a few degrees. From these experiments, however, as the lecturer very properly remarks, no positive conclusions can be drawn.—Lect. 6.

To ascertain the effects produced on the arterial pressure, when, instead of water or any other debilitating fluid, blood drawn from an animal of the same species as that on which the experiment is made, is injected into the vessels, M. Magendie took two dogs, of about equal strength, but somewhat differing in age, and gradually injected the blood taken from the carotid of the one into the jugular vein of the other, to the amount of more than a pound, without, however, obtaining any indication of an augmenta-

tion of pressure on the arteries—the elevation of the mercury so far from being increased, towards the close of the experiment, oscillated below its normal level.

"This," Magendie remarks, "is really difficult to comprehend, and I see no means of accounting for it, except by supposing that, instead of causing a simple mechanical effect, we brought some vital phenomena into play in the vascular system, by our introduction of a liquid, differing from that which ordinarily circulates through the frame. The blood of one dog is not precisely similar to that of another; there is, possibly, an individuality in the liquids of every animal, as there is in the external form of its body. The age, the size, the degree of strength, the kind of nourishment it habitually uses, give to each individual special and distinctive characters. The moment the foreign fluid touched the muscular fibre, it must have modified its contractile force, and hence, without doubt, arose the alteration in the energy with which the heart propelled the blood into the arterial system."—Lect. 9.

Another experiment was performed, in which the orifice of a syringe, capable of containing three-fifths of a pound, was introduced into and firmly fixed by ligature, to the carotid of a dog, so that it could be filled with the blood of the artery, and immediately throw back the same into the vessel, without any interruption to the contact of the contents of the syringe with the blood in circulation. The hæmodynamometer was applied to the femoral artery. Whenever the syringe was filled, and the volume of blood in the vessels of the animal in consequence diminished, the mercurial column of the instrument fell, and immediately rose again on the contents of the syringe being passed back into the artery. M. Magendie attempted to perform a similar experiment upon the jugular vein of the same dog, but failed in consequence of the instant death of the animal from the accidental introduction of a quantity of air into the vein. Lect. 9.

M. Poiseuille has established the following general theorem:—

"The total static force which moves the blood in an artery, is exactly in the direct ratio of the area of the circle of that artery, or in the direct ratio of the square of its diameter, no matter what may be its position in the economy."—Lect. 6.

After remarking that the velocity with which the blood moves through its vessels, has not yet been accurately determined, and that hence we are unable to allot to the pressure, and the velocity of that fluid, the influence that respectively belongs to them;

"You are aware," continues M. Magendie, "that the pressure and velocity are not always proportionate. The interest of these questions is not merely scientific; a number of useful precepts, bearing on the practice of medicine and surgery, may be derived from them. When, for instance, you tie an artery, the pressure you thereby remove from one point of the system, is distributed through its entire extent. The vascular apparatus forms a chain of which all the links are, in this respect, reciprocally vicarious. Thus, when you interrupt the circulation in the chief trunk of the lower extremity, for the cure of popliteal aneurism, the skin almost immediately acquires a burning heat, the face becomes injected; the pulse beats with force, the patient complains of flushes of heat; in short, all the signs of superactivity of the circulation ensue. This train of symptoms cannot be ascribed to the simple fact of a painful operation having been undergone; undoubtedly the wound has something to do with it, but the chief source of the fever is to be found in the modification of the hydrodynamic phenomena of the circulation. The force brought into play by the contraction of the left ventricle, struggles in vain against the resistance of the ligature; but that force is not uselessly expended; it is divided into as many partial forms as there

are sanguineous tubes, and increases the energy of the pressure in every part of the arterial system. Hence, the fulness of the pulse—hence the pulsations of which the patient is conscious, and which surgeons, who are generally more dexterous as operators, than as able physiologists, have been so embarrassed to explain. There are a number of cases, wherein the circle of the circulation is contracted. When you amputate a leg or a thigh, you diminish, by a fourth or a third, the extent of that circle; the pressure is, in consequence increased, as the tubes on which it acts are diminished in number. These mechanical notions will find their application in the precautions which it is expedient to take before and after operations of this nature. They prove that it is wise to disgorge the vessels artificially of some of their contents, in order to obviate the effects of the sudden augmentation of internal pressure. Under such circumstances, blood-letting may be of great service; managed with intelligence and discretion, it becomes a powerful auxiliary in therapeutics."—Lect. 6.

To prove, that by diminishing the extent of surface over which the blood flows, the force of its progression is increased, a number of experiments are detailed in the 6th lecture, in which, by pressure or ligature, the passage of the blood through different arteries was arrested, and the effects on the arterial pressure determined by the instrument contrived by M. Poiseuille. By these experiments it is shown, that when the static force of the blood is annulled in any given point, the impulse of the heart really becomes, as it was fair to anticipate would be the case, more energetic in the portion of the arterial system still traversed by the blood.

After referring, in lecture 9, to the proposition of M. Baudelocque, to apply compression, through the abdominal parietes, upon the aorta, as a means of arresting uterine hemorrhage after delivery, the lecturer proceeds to remark as follows:—

"The suspension of the flow of blood through so voluminous a vessel as the aorta, has a double effect; it immediately arrests the hemorrhage on the one hand—on the other, it diminishes the extent of the circulation; and, consequently, increases the pressure in the arteries situated above the compressed point. As the brain receives more blood, it is evident that the cerebral functions will acquire fresh activity: and, accordingly, we find that the patients recover their consciousness—that the face reassumes its natural colour, and that the prostration gradually ceases."

"It has been noticed, that one of the chief means of restoring an individual in a state of syncope to consciousness, is to place him in a horizontal position; in that attitude, the circulation requires less effort than in the vertical position, which easily explains its favourable effects. Perhaps we might act more directly on the encephalon, by compressing a large trunk; such as the brachial, the femoral, or even the aorta; in these subjects. According to the principles of hydrodynamics, the pressure of the cerebral vessels would become more powerful, and the nervous system consequently receive an increase of excitement."

Among the consequences which are found occasionally to follow the ligature of the primitive carotid in the human subject, is enumerated cerebral hemorrhage. M. Magendie relates one case, (Lect. 10) and seven or eight others are on record. In the Surgical Dictionary of Samuel Cooper, several are referred to; the hemorrhage in these instances, it is difficult to explain, inasmuch as in M. Magendie's experiments, the ligature of one of the carotids, produced no appreciable increase of pressure, and when both carotids, and one of the jugular veins were tied, the pressure was evidently diminished.

Having shown that the arteries perform a merely passive part in the great function of the circulation, M. Magendie proceeds in lecture 9th, to

consider the question, whether the heart's impulse is propagated from the arteries to the capillaries?

"As these two classes of tubes are continuous throughout," he observes, "it is extremely probable that such is the case; for, speaking in a mechanical point of view, it seems likely that the same force which acts at the origin of a system of ducts will continue its action to their termination.

"It does not require to be a profound anatomist to ascertain that a free communication subsists between the arteries and veins, through the medium of the capillary vessels. Push an injection into the spleen or kidney by the arteries, and it will return by the veins. None will deny this fact. But the litigated point respects the force that causes the fluid to move through the innumerable intervening canals. Well, you will see, that the heart acts in the living subject, as the piston of this syringe on the dead body, and they who refuse to acknowledge the reality of its action in this way, are in truth, refusing to admit the testimony of experimental observation.

"The further we advance from the central organ of impulsion, the more we find the rapidity of the flow of the blood diminished. The jerking movement of the arterial blood is very evident in the large trunks; it becomes less so in the secondary tubes, and is totally changed into a uniform motion towards the capillary vessels. Once arrived in the veins, the column of liquid moves extremely slow. The walls of these vessels are scarcely pressed on by the current that traverses them, and are collapsed in the ordinary state.

"The slackened flow of the blood in the capillaries, is a point which had not been fully explained previously to the latest experiments of M. Poiseuille. To that young physiologist we are indebted for some most interesting microscopical observations on the manner in which the liquids conduct themselves while traversing the capillary vessels.

"Among the most important facts he has discovered, are the following:—Whenever a liquid moves in a tube, a certain layer of it adheres to the walls of that tube, and remains motionless. If the course of the blood be examined under the microscope in an artery which has coats sufficiently thin to admit of the passage of luminous rays, the rapidity of the movement of the globules is found to be greatest in the axis of the vessel. This rapidity diminishes gradually, as we pass from the centre to the circumference of the vessel. There is a transparent space next to the internal tunic, which varies in breadth from the tenth to the eighth of the diameter of the tube, and is filled with the serum of the blood."

That this is no optical delusion, is shown by the movement of the globules. Some are occasionally detached from the central current, and brought thus nearer the peripheric motionless stratum; and, at the same time, their movement becomes much less rapid. Such as are jostled by their neighbours are dashed against the walls of the vessel, and become stationary. Hence, a translucid liquid, holding them in suspension, really exists, and communicates its immobility to them.

"In a large vessel, these different degrees of rapidity of the fluid molecules have hardly any influence on the movement of the central current. But if you suppose a tube of considerably less diameter, a greater relative quantity of the liquid will be motionless, and consequently, the central column moves in a comparatively narrow area. When the calibre of the vessel is still smaller, the stratum adhering to its walls, obstructs its interior almost completely, and a mere filament of fluid can, with difficulty, force itself a passage in the centre. Finally, when the degree of tenuity becomes extreme, the tube ceases almost wholly to be permeable to fluids."

"The adherence of a motionless stratum to the walls of the capillary vessels, is a capital fact, inasmuch as it explains how the course of the blood becomes slackened in those tubes. In order to surmount this obstacle, the left ventricle is obliged to dispense a part of its contractile force; but its power is far from

being exhausted, for it extends its influence even to the veins. Circumstances exist, under which the ventricular impulsion is quite as evident in the veins as in the arteries. Now, this impulsion cannot pass from the latter to the former, without affecting the capillary system in its way. If the movement of the blood in the veins were due to the action of the capillaries alone, the motion of the liquid in them would be uniform, and not in harmony with the causes which increase the force of movement of the arterial blood. The degree of the heart's energy, the respiratory movement, the volume of the liquid, would all of them be without influence on the venous circulation. Now we have testimony of daily observation, in evidence of the contrary. It is positively ascertained, that whatever acts on the flow in the arteries, acts also on that in the veins. My experiments had already demonstrated the existence of a close relation between those two great systems of tubes, when M. Poiseuille, by his late researches, gave us a mathematical solution of these important questions, and proved the futility of the theory, founded on an assumed action of the capillaries."

According then, to M. Magendie, the movement of the blood in the veins is chiefly effected by the heart's action, and by the elasticity of the arteries, which is itself brought into play by the contractions of the left ventricle. Among the accessary powers which aid in the circulation of the venous blood, he considers the movements of respiration to hold the first rank.

"The chest represents a pump, which, by means of its dilatation, aspires the liquid contained in the veins: when its walls expand, a tendency to a vacuum is produced, and the blood contained in the venæ cavæ rushes towards the right auricle; on the contrary, during expiration, those vessels are compressed, and the fluid they contain, repelled from the chest."—Lect. 11.

"The vascular trunks that traverse the abdomen to reach the right side of the heart, are influenced by respiration, but it is through direct compression of their walls, and not by the absence of equilibrium between the internal pressure and that of the atmosphere. In other words, when the chest expands, the abdominal viscera press forcibly on the venous trunks, diminish their diameter, and so drive the column of liquid where it can find an issue. The blood passes partly towards the thorax, and partly towards the lower extremities, but in the latter direction it encounters the valves which arrest its progress; it is consequently forced to push on to the chest, and its entry into that cavity is further promoted by the dilatation of the right auricle. There are, therefore, at first, two currents in opposite directions, which, however, almost immediately coalesce into one. Expiration follows, and the abdominal viscera, compressed by the walls of the abdomen, press in turn on the vessels. The same displacement of the columns of blood, the same play of the valves, and impulsion of the blood towards the thorax, are again produced. The blood contained in the abdominal veins and venæ cavæ, is evidently urged on towards the central organ of the circulation, during both movements of respiration. These phenomena have been very accurately described by M. Poiseuille, who has made numerous experiments in elucidation of the theory of their mechanism."—Lect. 11.

Several of these experiments were repeated by M. Magendie, and the details given in the lectures before us. Numerous experiments are also given to show the influence of respiration upon the circulation of the blood through the veins.

The hæmodynamometer being applied to the jugular vein of a dog, the mercury was invariably raised during inspiration, and fell during expiration, and always in proportion to the extent to which each of these respiratory movements were effected.

The dilatation of the chest in the act of inspiration is not, however, the only cause of the movement of the venous blood, nor is it indispensable to

that movement taking place. M. Poiseuille opened both sides of the chest of a dog, and then practised artificial respiration with a bellows. In this experiment, aspiration of the blood is at an end; the scale of the instrument applied to the jugular vein, showed an unvaried pressure upon the mercury, nevertheless, the circulation continued. This experiment, slightly modified, was repeated by M. Magendie, and with the same result. Hence the blood in the veins is manifestly influenced by the mechanical agents which augment its force of impulsion in the arteries.

"If," the lecturer remarks, Lect. 9, "the blood, when once it reached the capillary systems, were kept in activity by a motor power belonging to that system alone, it is evident that its movements through the veins would be invariably uniform."

Inasmuch as the ascent of the venous blood towards the chest is effected uninterruptedly, there must, M. Magendie remarks, be some other cause of the movement in addition to expiration, and the action of the left ventricle; that cause, he conceives, is to be found in the elastic reaction of the arterial tunics, consequent on their dilatation by each wave of blood propelled forwards by the heart.

"As for the proper action of the capillary vessels, be assured," he adds," that such action exists not in nature, but solely in the imaginations of those physiologists who have described it."

"In order to estimate comparatively the force of progression of the arterial and venous columns of blood, it becomes necessary to cause the blood driven by the ventricle through a single artery to return to the heart by a single vein. This has been done by M. Poiseuille; after having isolated the femoral vein and artery, he suspended the circulation in the thigh, by means of a ligature tightly applied to the limb, and he then ascertained that the amount of pressure was the same in the artery and vein."

A somewhat similar experiment was performed by M. Magendie, and with the same result.

Various facts, as well as the experiments detailed in the present lectures, show that the pressure supported by the veins is much inferior to that sustained by the arteries. Now, as the principle of movement in both systems, resides in the heart, the question arises, why is it that the hydrodynamic phenomena of the circulation are identical in every part of the vascular system? This arises, according to M. Magendie, from the difference in the structure and arrangement of the two sets of vessels in which the blood circulates—the coats of the arteries being firm and elastic, and those of the veins flaccid, almost entirely devoid of elasticity—the arteries decreasing constantly in dimension, in proportion as they pass from the heart, while the diameter of the venous tubes augments as they approach that organ; hence in the arteries the current of the blood is most rapid at its origin, in the veins at its termination—the arterial tunics being constantly distended by the blood, while the coats of the veins are frequently collapsed—and the veins being provided with valves to prevent the reflux of the blood, while the arteries are destitute of such contrivance.

"The pressure is uniform throughout the arterial system, extremely various in the different parts of the venous. The physical properties of the circulating fluid differ in the two classes of vessels, as well as the character of its movements—in the one the current is rapid, in the other slow. But the two departments of the vascular apparatus differ most widely in respect of the number and capacity of their component tubes."

After showing how much the number and capacity of the venous branches exceed those of the arteries, the lecturer continues:—

"The arteries, from their position, structure, and the direction of the currents that traverse them, are independent of the majority of causes that slacken the movement of the blood in the veins."

"Although the pressure exercised by the liquid in the interior of the venous trunks is feeble, we have clearly seen that it does exist to a certain extent." "In attempting to explain this diminution in the influence of the heart, we must not forget to take into account the obstacle to the movement of the blood produced in the capillaries by the adhesion of a motionless stratum to their walls. But although this phenomenon has a decided influence on the velocity of the venous blood, still it is far from being of such consequence as might be supposed. The greater capacity of the venous tubes, as compared with the arterial, is the chief cause of the diminished progressive force of the current within them. If you represent by *one* the capacity of an artery, and by *ten* that of the veins which succeed to it, it is clear that each vein will only receive a tenth of the force that moves the blood in the artery. The impulse of the ventricle is divided, but not lost, in the venous system. This is so true, that when we cause the entire mass of blood conveyed to a part by an artery to return by a single vein, the pressure is found to be very closely equal in the two vessels."—Lect. 10.

The lecturer details several experiments, performed by him, to show the influence of variations of temperature upon the circulation of the blood. The blood in the living vessels, according to M. Magendie, is almost as directly influenced by the temperature of the atmosphere, as the mercury in the barometer.

"Every one is aware," he remarks, "that, during very hot weather, the face is more highly coloured than at other times, and the movements of the heart more rapid. A greater quantity of blood is constantly passing through the vessels, and the cutaneous and pulmonary exhalations are very sensibly increased in quantity; hence the craving we feel for aqueous drinks, in order to restore to the blood the water it is constantly losing. But it is on the capillary circulation more especially, that the temperature of the blood exercises a very manifest influence."—"The variation of heat acts not only on the blood in the capillary vessels, but dilates the membranous walls of the latter, enlarges their cavity, and modifies the hydrodynamic phenomena. Pulsations are felt where they did not exist before—several globules now pass abreast in the tubes, which before scarcely allowed of the passage of one; in a word, a new state of things discloses itself for the investigation of the physiologist."

"When the practitioner wishes to increase the activity of the circulation in an individual, and facilitate the passage of the blood through the whole vascular system, he orders a warm bath: its effects are soon felt through the entire frame. The respiration becomes accelerated, because as a greater quantity of blood arrives in the lungs within a given time, a greater quantity of oxygen is required; the tissues swell, and the external surface grows red. Again, if the object be to diminish the activity of, for example, the cerebral circulation, and to increase that of distant parts, you make use of pediluvia. The phenomena ensuing are precisely the same as in the preceding case, except that they are simply local. Instead of acting on the entire vascular system, you limit the action of the elevated temperature to a few of its tubes. This, too, is an exclusively physical result. Let us take an example of the opposite kind: An individual puts his hands and feet in snow—the fingers and toes immediately become white, in consequence of the reflux of blood to the central parts of the limbs. The capillaries of the periphery of the body, when submitted to the action of sudden cold, become unfit for carrying on the circulation. Part of the fluid they contain passes into the veins, and, as they no longer admit that which the arteries carry to them, they are really for a moment empty."—Lect. 5.

This M. Poiseuille has proved by direct experiment:—

"Cold baths," observes the lecturer, "are recommended in cases where the indication is to soothe general excitement, characterised by excessive activity of the circulation. When the forehead burns, and the temporal arteries beat violently, we apply ice, or some frigorific fluid, to the part. When too much blood flows to the brain, we have recourse to cold affusion."—"The treatment of fractured limbs, by constant irrigation with cold water, furnishes another example of this mode of action. The prolonged continuance of a low temperature diminishes the vascular pressure, prevents blood from rushing in the natural quantity towards the seat of the lesion; in a word, prevents the phenomena called inflammatory from taking place. When we plunge into cold water, during very warm weather, a peculiar sort of constriction is felt at the thorax. This again is a purely physical phenomenon. Less blood traverses the capillaries, consequently it accumulates in greater quantities in the larger trunks—these distended as they are, press on the neighbouring organs; hence the uncomfortable sensation of which the patient is conscious. It disappears when the equilibrium of temperature is restored throughout the sanguineous system; and so the sudden immersion of the whole body renders its effects much less sensible."—Lect. 5.

To ascertain the variations in the pressure the blood exercises on the vessels according as the temperature of the tissues is high or low, M. Magendie instituted experiments in which the hæmodynamometer, substituting a solution of subcarbonate of soda for the mercury, was applied to the vein of the lower extremity of a dog, the rest of the limb being immersed at first in a frigorific mixture, and subsequently in compresses saturated with hot water; from which it was found that the movement of the blood was evidently rendered slower by the cold, and quickened by the rise of temperature.

To determine with accuracy the effects of directly cooling the blood, M. Magendie injected a quantity of cold water into the veins of a middle sized dog, and applying the hæmodynamometer to the carotid artery—the blood, after the injection, was found to be reduced 7 or 8 degrees below its normal standard—yet, notwithstanding this and the presumed debilitating action of the water, the vascular pressure as indicated by the instrument was rather increased than diminished.—Lect. 5.

A few remarks are offered, Lect. 12th, on the reflux movement of the blood in the vessels, or its occasional flow in an artery directly opposite to the normal direction. According to the lecturer, two mechanical agencies appear to concur principally in the production of this reflux of the blood—the elastic retraction of the arterial coats at the moment the left ventricle expands, and anastomotic communications. When an artery is cut across, both ends retract on themselves, and consequently the blood rushes towards the points where there is least resistance. It will, therefore, chiefly direct itself towards the divided extremity.

"But the flow of blood will not stop the moment the coats of the vessel retract; the anastomotic branches, opening into its interior, keep a constant current in movement within it. The blood travels freely, in the contrary direction to that of its natural course, towards the solution of continuity, more especially where several trunks open into each other, as at the base of the skull. Surgeons who have recommended the ligature of both ends of a divided artery, have given us a wise precept; they have not, however, described the physiological foundation of it."

M. Magendie measured the force with which the blood tends to obey the retrograde movement with the hæmodynamometer. The instrument

was applied to the primitive carotid of a dog, a ligature having been previously placed around it, and it was found that, in consequence of the anastomotic communications which unite this vessel with the opposite carotid and the vertebral arteries, about the same amount of pressure was indicated in its superior and inferior ends—that is, in the end on the side of the ligature nearest the heart, where the pressure resulted from the action of the latter, as well as in the end on the opposite side of the ligature where the pressure can be produced only by a reflux movement of the blood.

In proceeding to consider the circulation through the capillaries, the lecturer notices, first, the extreme minuteness of these vessels, and the peculiar properties of the blood which enables it to traverse tubes of so small a calibre.

The diameter of the capillary vessels has been computed to be about the 1.150th or 1.200th of a millemèter.* Now it is with the greatest difficulty we can succeed in forcing *water* or any analogous fluid through glass tubes of only 1-10th of a millemètre in diameter; and it is almost impossible to drive a liquid through tubes of a smaller diameter, no matter what force be employed. We meet with the same resistance in injecting *water* into the mesenteric artery of a frog, with a view to force its passage into the continuous vein. The fluid employed is, in a great part, extravasated into the surrounding tissues, and but a small quantity reaches the desired point.

"My inquiries up to the present time," the lecturer remarks, "go to prove, that the passage of the blood, from the arterial to the venous capillaries, is effected by means of a nice adaptation of its physical properties to the physico-vital endowments of the vessels."—"That if a single one of the properties of that fluid be modified, its movement through the capillary system becomes impossible."

It is to the viscosity of the blood, mainly, that M. Magendie attributes its capacity to traverse the capillary vessels. The viscosity of the blood he pronounces "an indispensable condition for its free circulation." This property he illustrates by experiments on inorganic tubes. Thus, notwithstanding the impossibility of introducing water into a tube of extremely small diameter, whatever force we employ, yet, if any mucilaginous substance, as gum, gelatine or albumen be added to the water, it may be injected with ease. This fact is proved by some ingenious researches of M. Poiseuille. M. Magendie considers that the blood, circulating in our organs, may be justly assimilated to the fluid in the experiments just alluded to. If deprived of its viscosity, its further passage becomes quite as impossible as that of the non-mucilaginous water; it stops at the entry of the capillary system, is extravasated into the surrounding tissues, and causes the disorders ordinarily ascribed to irritation and inflammation.

To prove that the viscosity of the blood is the property which enables it to circulate through the minute capillaries, several experiments are detailed by the lecturer. Thus successive portions of blood were removed from an animal, and subsequently re-injected into its veins, it being first, however, deprived of its fibrine—symptoms of great gravity came on almost immediately, and the animal soon perished. Its blood had become so utterly unfit for circulation in the capillaries, that it was extravasated into

* A millemètre equals the 0.039370 of an inch.

the various tissues, but especially into the parenchyma of the lung, to which it gave the appearance of a huge clot.

Into the veins of another animal were injected 25 grammes* of subcarbonate of soda, which has the property of rendering the blood more fluid and preventing its coagulation. Death was instantaneous. The lungs were found distended with fluid blood, which gushed out when an incision was made into their substance; bloody effusion existed also in the pleura; the various abdominal organs were healthy.

After enumerating the twenty-five distinct substances which M. Lecanu describes as existing in the blood, the lecturer adds the following remarks:

"Now it is very possible that the number may be really still greater, but counting according to this analysis, there are only twenty-four in the specimen I show you. The absence of one of its normal constituents is not perceptible by any outward sign; the sample before you appears perfectly identical with the blood that circulates in the living animal. Yet, notwithstanding this apparent similarity, its properties are different, for if I re-introduce it by a vein, it will, at first, pass through the large vessels, but, on reaching the capillary system, its progress will be arrested, and the animal will soon perish of the disorders induced by the stoppage of the capillary circulation. Now nothing has been added to this blood; I have simply removed from it one of its elements—an element, too, that at the utmost forms no more than from 1.1000 to 2.1000ths of its volume. That element is fibrine, which, while in the vessel, is liquid; but, when removed from them, becomes solid; and hence it is to its *fibrine* the blood owes the extraordinary property it possesses of passing through the capillary system. But this is not the only important fact affecting the fibrine; indeed, were we to take this alone into account, we should fall into a very serious error. Let us suppose an animal whose blood contains fibrine, as well as all its other constituent parts, in the normal proportions. If I inject into the veins of such an animal any substance possessing the property of combining chemically, of forming salts, with the fibrine, such as fibrinate of soda, potassia, or ammonia, that fibrine will lose its coagulability. The change in the characters of the fibrine affects the blood generally; it ceases to be coagulable, and the usual consequence ensues."—Lect. 3.

"In order to support life, the blood must be coagulable; if it loses that property, existence is threatened, and ceases within a short time; and this is precisely what occurs in the greater number of destructive epidemics. They are specially connected with certain modified conditions of the blood, that cause it to stagnate in the pulmonary vessels. Such was the state of things in the epidemic—the '*grippe*'—by which we were lately visited.

"Now, even at the present stage of our acquaintance with the properties of the blood, we are enabled to take a different view from that ordinarily held concerning the nature and origin of *local* and *general* diseases. In the former case, the blood becomes obstructed in the pulmonary capillaries, and a local lesion of those organs—either apoplexy, hemorrhage, or hepatisation—follows. In red hepatisation, however, the blood does not cease altogether to be coagulable; in fact, the compact, hard, resisting masses, formed in the areolæ of the organ during the course of pneumonia produced by any external cause, are nothing more than clots of blood. But in the *false pneumonia* of the '*grippe*,' it is totally deprived of the property of solidifying, is effused into the parenchyma of the organs, and causes the blackish serous infiltration met with in the victims of that epidemic. But let us admit that the altered circulating fluid has succeeded in getting through the pulmonary vessels, it passes to other organs, and in some of them, as, for example, in the intestinal mucous membrane, encounters capillary vessels of still greater tenuity than those of the lungs. The mechanical obstruction here produces redness and ulceration of the follicles—the organs of

* The gramme equals 0.0648 grains.

digestion lose their power of assimilation, and the whole economy suffers from the same shock."—"In acute rheumatism, the painful parts become the seat of engorgement due to the stoppage and accumulation of the blood in its canals. The liquid stagnates, its temperature falls, and hence the sensation of cold felt by the patient, and which may, in some cases, be felt by a bystander on the application of the hand."

We have made the above copious extracts from the 3d lecture of M. Magendie, as well in consequence of their containing many important particulars in reference to the circulation of the blood, as an exposition, in his own expressions, of some of the lecturer's pathological views.

As further proof that a certain degree of viscosity, is an essential requisite for the healthy circulation of the blood, M. Magendie adduces the fact deduced from actual experiments; that if an animal be bled several times, and the blood drawn replaced with water, exhalation and effusion into the cavity of the pleura, and subsequently into the peritoneum will ensue, in consequence of the viscosity of the blood being reduced by the water introduced.

When the viscosity of the blood is artificially *increased* beyond its natural term, the circulation ceases entirely, in consequence of the affinity between the molecules of the blood being rendered too great; hence, the lecturer remarks, there must be diseases originating in excessive viscousness of the blood. In the experiments to exemplify this point, a viscid matter, as gum, for example, dissolved in water, and coloured was injected into the jugular vein of an animal. As long as this mucilage traversed the large venous trunks, no disturbance resulted, but so soon as it had arrived by the pulmonary artery, in the minute ramusculi of the lung, its degree of viscidity ceased to be in just proportion to the capacity of the tubes. The consequence was, that the circulation almost instantly stopped, and as the brain no longer received the necessary excitement of arterial blood, its functions ceased, and the animal quickly perished. On cutting, after death, the parenchyma of the lungs, perpendicular to the direction of its principal vessels, they were found invariably clogged up with the matter injected. But the lecturer remarks, let us suppose the substance to have passed with great difficulty through the pulmonary vessels; arriving at the capillaries of greater tenuity, it will, beyond question, be arrested in its course by this new obstacle; and its stagnation and subsequent effusion, will produce, according to the nature of the parts with which it is in contact, various disorders, more or less analogous to those already described.

"I mentioned," says M. Magendie, "gum as a substance that increases the viscidity of the blood. I may add that oil and starch, and all amylaceous matters, generally, possess the same property. Besides, similar modifications arise spontaneously in certain diseases. Thus we sometimes meet with blood so extremely viscid, that it has very nearly the same consistence as, to use the language of pathologists, currant jelly. I showed you several cases of this kind, both natural and artificial, and you saw that the most perfect analogy always existed between the phenomena produced by the unknown causes of disease, and by my experiments. In every case in which you find the blood clotted in this manner, you may rest satisfied, that the lungs have been the seat of some profound lesion. We have ascertained that the alkalies liquify the blood, and it is similarly demonstrated, that certain acids, sulphuric among others, increase its viscidity, by combining with, and solidifying its fibrine. Nay more, I have proved, as in every other case by experiment, that prolonged inanition, produces the same result; the blood loses its aqueous principle, and tends to solidification."—Lect. 4.

M. Magendie has shown that, to enable the blood to traverse the capillaries, a harmony must exist between its globules and the calibre of the latter tubes. Thus, when in his experiments, he introduced into the blood-vessels of an animal, the globules of the feculæ of corn or potatoes, which are perfectly innoctious in their properties, but vary from one-twentieth to one-tenth of a millemètre in diameter, an obstruction of the capillary vessels was produced, followed by dyspnœa, cough, prostration of strength, and similar lesions were exhibited after death, as result from excessive viscosity of the blood. When, however, globules of a similar kind, but of infinitely smaller size were introduced, the circulation experienced no interruption. Thus, some of the fecula of the *mirabilis jalapa*, the granules of which are only one-three hundredths of a millemètre in diameter, were injected into the veins of a dog, no notable disturbance followed. A larger quantity of the liquid containing the fecula being subsequently introduced, the animal was seized with dyspnœa, and died in a few hours, and the lungs exhibited the same appearances as in animals destroyed by the injection of oil or starch. In this case, the fecula had lost nearly all its water by evaporation, and when injected was very viscid—"it was, therefore," M. Magendie remarks, "its viscidity, and not the size of its globules which caused the death of the animal.

In another experiment, M. Magendie injected a drachm of varnish, holding some sifted porphyrised animal charcoal in suspension, into the femoral artery of a dog—the consequence was, that mechanical obstruction of the capillaries of the limb took place, the circulation was suspended, and on the third day, the leg presented all the characters of confirmed gangrene.

It appears to M. Magendie to be improbable that corpuscula of very large size, in comparison with the diameter of the capillaries, can directly enter the circulation. He conceives, however, that some chemical agent or other may be absorbed, and entering the circulation, modify the globules, or some one of the elements of the blood.

"A chemical process commences, and granulations are deposited in the interior of the minute vessels, block it up, and arrest the motion of the column of blood. It is in this manner, that a concentrated acid injected into the stomach, causes death, by coagulating the albumen of the blood, and obstructing the flow of that fluid mechanically."—Lect. 20.

It is to mechanical obstruction in the blood-vessels, either from the particles of matter suspended in the blood being too large for the diameter of the tubes, from too great a viscosity of the blood, or from a tumour developed among the tissues pressing on the vessels, and other analogous causes, by which the movement of the blood is arrested, that M. Magendie would seem to attribute the production of the majority of cases of spontaneous gangrene. The *dry* and *humid* gangrene of nosologists, differ, according to his views, solely in the quantity of fluid present in the affected part.

"It is probable, that the first species originates more particularly in some obstruction to the arterial circulation, whereby the passage of the blood through the capillaries is prevented; while the second would appear to be principally brought about by venous obstruction and consequent non-return of blood to the heart."—Lect. 21.

Two hundred grammes of quicksilver, the particles of which are too large to force their way in the living subject, through the ultimate ramifications of the blood-vessels, were injected into the right primitive carotid

of a dog, and the animal was immediately affected with all the symptoms characteristic of an *ictus sanguinis*, and died in a few minutes. On opening the skull, minute drops of the metal escaped from the lips of the incision, showing the facility of anastomotic communication between the two external carotids; on denuding the brain, the pia mater presented the appearance of a silvery pellicle, spread over the nervous substance. The brain and cerebellum being invested on all sides by a network formed of the minute blood-vessels, into which the injected fluid had penetrated. The column of quicksilver seemed to terminate abruptly at some points, where no doubt the globules of the metal were too large to penetrate any further. Such was the uniformity of distribution of the injected fluid, that it was impossible, by the simple inspection of the vessels of the pia mater, to determine in which of the two carotids it had been introduced.—Lect. 20.

M. Magendie remarks, (lecture 5,) that a phosphuretted fatty matter has been discovered in the blood, analogous to that of the nervous matter, and like it causing instant death, when re-introduced into the blood by injection. M. Pinel Grandchamp states, that the injection of half an ounce of this substance, into the veins of a furious buffalo, proved almost instantaneously fatal. "Now death, in this instance," adds the lecturer, "is a purely mechanical result; this I demonstrated clearly last year. The nervous pulp acts solely by obstructing the minute capillary tubes; it is otherwise inoffensive.

We cannot spare sufficient space to notice all the interesting facts, presented in these lectures, and derived chiefly from the microscopical observations of M. Poiseuille, in relation to the phenomena which the blood exhibits during its passage through the capillary vessels.

The following experiment of M. Poiseuille, proves in the clearest manner that the movement of the blood through the capillary system depends on the impulsion of the heart and the elastic retraction of the coats of the vessels.

"The femoral vein, artery and nerve of a frog are accurately separated to the extent of two centimetres, (nearly four-fifths of an inch,) at the least, from the surrounding tissues, and a ligature then passed round the thigh, excluding the vessels and nerve; a loose ligature, ready to be tightened at will, is thrown round the vein. A thread is next fixed to the extremity of each digit of the same limb, to facilitate the examination of the circulation in the interdigital spaces, without modifying it by pricking the tissues. The frog being pinned down to a flat piece of cork, and the web laid under the object-glass of the microscope, the ligature embracing the bone and muscles of the thigh is forcibly tightened. The experimenter is then certain, that the circulation in the lower part of the limb is carried on by the dissected vessels alone. The circulation in the arteries, veins, and capillaries, goes forward in the same manner as before the performance of the operation described; jerking movements sometimes take place. The globules move more rapidly in the arteries than in the veins; and in the capillaries, their velocity is less than in the other two orders of vessels; in some, however, it is greater than in others, for reasons to which we need not at present direct our attention. The observer now watches with especial care, an artery and vein of the interdigital space submitted to investigation; he then interrupts the course of the blood in the femoral vein; the moment he does so, the progression of the globules in the vessels of the digital interspace becomes jerking, and this jerking mode of progression lasts a few seconds only, being followed by an oscillatory movement. The span of these oscillations at first equals the length of five globules, and soon decreases to that of two; the rhythm is identically the same in the artery and capillaries of the interdigital space, and they continue to the number of forty-six in a minute, so long as the compression of the vein is kept up. While the femoral vein still undergoes compression,

the experiment is varied by interrupting the course of the blood in the artery also; the oscillatory motion ceases at the same instant. The globules become quiescent in the artery, the capillaries, and veins of the extremity. If the femoral artery be then freed from constriction, oscillations of equal length in the three orders of vessels recommence. These experiments concluded, the heart of the animal is laid bare, and the number of the contractions of the ventricles counted; these are found to be one hundred and eighty-six in four minutes, or forty-six in a minute.

"*Remarks.*—The oscillations of the globules are produced on the one hand, by the heart, which impels the blood into the arterial system, into the capillaries and the veins; on the other by the retraction of the arteries and veins that follows their dilatation by the wave of blood driven forwards by the left ventricle."—Lect. 13.

In his 7th lecture, M. Magendie notices the influence of moral impressions, and all strong sensations, whether painful or pleasurable on the circulation, by altering the rhythm and energy of the heart's contractions, and the effects of muscular action in favouring the passage of the blood through the veins.

In proceeding to a consideration of *the blood itself*, the lecturer points out (lecture 7,) a fundamental fact, necessary to be kept constantly in view, the difference, namely, between the blood in the living animal, and that extracted from the body.

"When," he remarks, "we examine such vessels of an animal under the microscope as are sufficiently transparent for the purpose, we distinctly perceive an infinite number of globules, borne along by a rapid movement, rolling and slipping over each other; and we see, besides, between the mass in motion, and the walls of the vessel, a space almost destitute of globules, and filled with a colourless transparent fluid. This fluid is the *liquor sanguinis*, which holds the globules in suspension during life."

"The *liquor sanguinis* is, no doubt, in reality, serum; but serum which holds in suspension, or in solution, the coagulable matter, or fibrine of the blood."

If you allow some of the blood to flow from the living vessels into a vase—

"A clot will form, and the globules disappear, while within the vascular tubes, they move in the midst of a viscid fluid." "In a vase solidification takes place; one of the elements of the liquid, the fibrine, becomes organized, and imprisons the globules in its cellular structure. In the living subject the serum contains the globules and fibrine in suspension, removed from the body that liquid bathes, a clot composed of fibrine and globules."

"Still of the two parts, the serum and the clot into which the blood separates, when out of its natural tubes, examine the latter, and you will find that the liquid dissolves the globules. The fibrine will alone remain, and you will be astonished at its minute quantity, compared with the dimensions of the clot, and the enormous number of globules it contained."

It appears to M. Magendie, that the condition of the fibrine in the serum, is most probably that of suspension. He believes that the fibrine, instead of being a kind of precipitate in the blood, exists in that fluid in the form of *minute vascular arborisation*, forming, in a certain sort, the first degree of organization."—Lect. 5.

"The *fibrine*," the lecturer remarks, "is alone, at once the cause and the agent of the solidification of the blood."

"If you examine," he remarks, "one of these masses of parenchymatous fibrine, (a portion of fibrine deprived of red globules,) under the microscope, you will detect a regular conformation in it resembling the forms assumed by orga-

nized matter, such as ramifications and areolæ, intermingling and anastomosing in an infinity of ways. The clot then, the *insula* of the ancients, must not be looked on as an inert mass, but as a fibrinous arborescent matter, forming the basis of a finely and delicately organized parenchyma, and differing essentially from the albumen, the solidification of which is the simple result of a chemical or physical agency. But the functions of the fibrine do not stop here. It is to be found again, with the same characters, in the coagulum which obliterates divided arteries or veins: it is to be traced in the formation of adhesions, of false membranes, and of cicatrices; and it is to be seen deposited in layers at the surface of solidified wounds. Under all these conditions it is organized; its arborisations are converted into pseudo-membranes, and these false membranes become canaliculated, forming vessels permeable in their turn, by the liquid that produced them, and of which they originally helped to constitute the substance."—Lect. 7.

To prove that the fibrine is the agent by which the adhesion of cut surfaces, and the obliteration of ligatured vessels are effected, M. Magendie made a longitudinal incision through the skin, and some depth of muscle in a dog, from whose blood the greater part of the fibrine had been removed, the lips of the wound were accurately united by the twisted suture, and the animal left to himself; after a few days he died, when, on examination, the lips of the wound were discovered to be dry, discolored and scarcely at all swollen, but presenting no real adhesion.

In the same animal, a ligature had been applied to the right carotid; on slitting up the vessel and examining its interior, no trace of coagulum existed; the ligature had nearly divided the coats, and had the animal survived a few days longer, it is evident that secondary hemorrhage must have occurred.—Lect. 7.

The solidification of the fibrine in blood drawn from the body, M. Magendie considers to be an action occupying a middle place, if he may so express himself, between *vitality* and *inorganism*. This he infers from its property of spontaneous coagulation, and forming always in its solid state a real texture or parenchyma, constituted of filaments crossing each other in a variety of directions, and adhering together so as to form cells, irregular in shape and size, resembling those discovered by the microscope in our most delicate tissues. Lect. 11.

This will be rendered more evident by receiving the blood into a vessel containing sugar and water, in which case, the fibrine will be obtained separated from the globules. One of the most remarkable circumstances, the lecturer remarks, connected with the formation of these networks of fibrine is, that whatever be the quantity of water that is added to the blood, provided the latter contain the least share of fibrine, that fibrine will detach itself from the rest of the fluid in the shape of long filaments, which contract adhesions with the inner surface of the vessel, interlace, become agglutinated together, and so form an undulating network, modelled to the shape of, and filling the whole interior of the vessel. In a mixture of $154\frac{1}{2}$ grains of blood with six times that weight of water, the fibrinous network was perfectly distinct, and after this was removed, a second one of still more cloudy appearance than the first was perceived. Lect. 12.

M. Magendie notices, in the same lecture, the strong resemblance which exists between the species of membrane formed by the fibrine, and rendered evident by receiving the blood in vessels containing a portion of sugar and water, and those lining the uterus during the early period after fecundation. At that period, the uterus undergoes a particular modification: and the lec-

turer is inclined to believe that the distension its tissues experience, dilates the orifices of the vessels terminating in it; the blood is distributed to it in greater quantity than usual, its fibrine transudes on the fœtal surface of the organ, and forms the membrane placed between it and the ovum.

The buffy appearance of the surface of the clot which is occasionally met with, and which was formerly considered as an invariable indication of the existence of inflammation and the necessity of blood-letting, M. Magendie has shown to be nothing more than a portion of fibrine, which, as it is lighter than the colouring matter of the blood, whenever the coagulation of the clot is sufficiently slow to allow it, rises to the top, and forms on the upper surface of the liquid. It is often absent in cases of evidently intense inflammation, while it is as often present where the existence of inflammation or other disease cannot be suspected.

"The modification in the coagulating process, which produces the buffy coat," observes the lecturer, "depends on a variety of circumstances. Thus, although inflammation evidently exist, if the opening made in the vein be narrow, or if its parallelism with the wound of the integuments be imperfect, and the blood flows slowly; or if the receiving vessel does not present a wide, and, according to others, a narrow, surface to the air, the *buff* refuses to show itself."—Lect. 7.

If four parts of sugared water, and one of blood be well shaken together, and then allowed to settle, after a certain lapse of time, the white clot will be perceived at the upper part, in consequence of the sugared water facilitating the precipitation of the globules.—Lect. 19.

This buffy coat which is only an occasional occurrence in human blood, is almost constantly present in that of the horse, and there ordinarily forms two-thirds of the total mass of the clot.

"In cases," M. Magendie remarks, "where a buffy clot is about to form, some yellowish serum is observed to accumulate on the surface of the blood; this is especially remarkable in the instance of the horse. Now, if this serum be removed, it will coagulate like the fibrine itself, and the same process will go on, until all the fibrine of the blood has coagulated. I have remarked this fact, which struck me not a little, the first, as I had fancied, but it appears that Dr. John Davy noticed it before me, in his researches on the coagulation of the blood."—Lect. 20.

According to the lecturer, so long as the clot, which is constituted chiefly of coagulated fibrine, holding entangled in its meshes, the red globules, forms about the fourth of the entire mass, there is a species of equilibrium of composition, which coincides with the state of health.—Lect. 9.

When removed from the body, the blood presents itself under two very distinct conditions. In some cases it forms a compact mass, its superior surface being of a bright red colour, the lower portion blackish: in other instances, it separates into two perfectly distinct parts—the clot and serum. In certain cases of disease, the blood either coagulates very imperfectly or remains entirely fluid.

The causes that deprive the fibrine of the capability of clotting reside, according to M. Magendie, in the air, in miasmata, in our food and drink, and, in short, in every agent surrounding us that penetrates into the economy, no matter by what route. In cases of asphyxia by lightning and carbonic acid, the fibrine also loses its power of coagulating. The lecturer found, also, by experiment that the section of the eighth pair of nerves likewise destroys the coagulability of the blood. Whether by a mediate or immediate action, he is unable to decide. Compression on the brain was

artificially produced, by injecting through a small opening made in the skull of an animal, beneath the pia-mater, a sufficiency of liquid, to determine the characteristic phenomena of compression of the brain, and then blood was drawn from an artery. The clot formed by this blood was tremulous, undulating, and so far from being of the healthy firmness, the simple weight of a small glass rod was sufficient to break it in two.—Lect. 16.

The fact that gives its chief importance to the study of the property of coagulation in the blood, is that, as M. Magendie has demonstrated, the loss of this property, no matter under what circumstances it occurs, is followed invariably by death.

The coagulation of the blood may be prevented by either diminishing its amount of fibrine or destroying in the latter its property of spontaneous solidification. The amount of fibrine in the blood may be so far reduced by repeated bleedings or spontaneous discharges of blood as to be no longer capable of coagulation. A female was admitted into the wards of M. Magendie at the Hôtel Dieu, with most *violent uterine hemorrhage*, which had existed for two days at the time of her admission. This was the consequence of an artificial miscarriage, induced by the use of powerful drugs. It was not her first attempt in this way; she had already succeeded twice or thrice in producing abortion. The general pallor of the patient was very remarkable, as well as the state of prostration and stupor under which she laboured.

"Her blood," remarks M. Magendie, "trickled away in diffluent clots of a peculiar odour; it was this, indeed, that turned my thoughts to the probability of a premature delivery having taken place; this, however, the patient employed all her remaining strength in pertinaciously denying. I had two ounces of blood taken from her, to enable me to prognosticate the probable issue of the affection. Here is the blood: the disproportion of its elements is frightful; there is only 15 per cent. of coagulum. I affirm, that with such a quantity of serum in the blood, the capillary circulation cannot be regularly accomplished. I have before me a new proof of the fact, in the lung of an animal, submitted to successive bleedings. At the eighth, the blood was so profoundly altered in its qualities, that it was impossible to continue the experiment, for the following reason:—Blood can only be removed from the body through an artery or a vein. In the case of the arteries a clot forms, after the operation is finished, which mechanically blocks up the cavity of the vessel; but if the blood have lost the property of clotting, of course, no coagulum is produced. In the case of the veins, the edges of the wound become glued together, and unite in such a manner as to leave the cavity of the vessel free; but in the condition of the blood referred to, no adhesion takes place. You may tie the artery, and heap ligature on ligature, but in vain; they cut through the vascular tunics, and the hemorrhage reappears in a more threatening manner than before. As the very simple cause of these deplorable occurrences was not formerly understood, they were quasi explained by a term without the least real meaning: they were ascribed to the *hemorrhagic diathesis.*" "You are aware what difficulty is encountered in the attempt to stop the flow of blood in some individuals, after the application of leeches, or the trifling operation of cupping." "But to return to the animal: he died of hemorrhage; and, according to my theory, we should find an affection of the lung, engorgement, œdema, or possibly, even true pneumonia; and, as I had supposed would be the case, we discover, on cutting into the organ, that serosity oozes from its substance. This is nothing more than the serum of the blood, extravasated into the vascular areolæ, because the blood had lost its just degree of coagulability. What can have deprived it of that property, unless it be the bleedings the animal underwent? Hence, that operation was the real

cause of the animal's death, as it was so frequently repeated as to render the blood almost, or completely non-coagulable."

"There is something very remarkable, in a pathological point of view, in the case of the woman with uterine hemorrhage, and whose blood gave but 15 per cent. of coagulum. At the end of forty-eight hours, during which every drug supposed to possess antihemorrhagic virtues was employed, among the rest secale cornutum, *peritonitis* supervened."—"Now, can you fancy that the attack of peritonitis was the result of excitation, or irritation, suffered by the patient? She was, on the contrary, perfectly anemic, and in the most marked state of weakness—and peritonitis is so acute a disease, that it carried her off in less than four and twenty hours. Is no relation to be recognised between the liquidity and slight coagulability of the blood, and the affection of the peritoneum? But this is not all; if we turn from the abdomen to the lung, there, too, we find a state of engorgement, in other words, serosity effused; in short lesions perfectly analogous to those detected in the lung of the animal submitted to repeated blood letting. I may, therefore, legitimately conjecture, that these diseases are to be referred to particular conditions of the blood also. I also discover a substance solidified in the form of very thin lamellæ,—may I not suppose that this is the fibrine of the blood escaped from its vessels, and become organized? This idea has, indeed, been already broached, and nothing has hitherto shown it to be fallacious. The relation that may possibly subsist between the composition of the blood and the development of peritonitis, especially in cases where it follows hemorrhage from abortion, and forms a most serious complication of puerperal fever, seems to me a point of the deepest importance, and worthy of our most anxious attention."—Lect. 9.

In dogs bled to a considerable extent, the fibrine being immediately after the operation separated with care, and the rest of the fluid then injected into the veins; from the period of the operation the animals lie on their side, as if their limbs had lost even the share of strength necessary to support their body; the respiration at once becomes plaintive; the movements of the animals are few and difficult, and they appear to have lost the power of hearing. In addition to all this, sanguinolent motions are passed, resembling very closely the alvine dejections in dysentery, caused probably by the escape of the blood through the coats of the vessels on the surface of the mucous membrane; a sort of eruption generally occurs, resembling, in no slight degree, the petechiæ of fever, and, like them, apparently produced by exhalations of blood into the substance of the skin—the animals become usually quickly affected with a species of purulent ophthalmia.—The conjunctiva assumes a fungous, pulpy appearance, becomes covered with a greenish film, and the cornea strewed with round superficial ulcerations, which augment in size and finally perforate the membrane. The blood, deprived of its fibrine, ceases to follow the course of the vessels, but oozes through their walls, just as if these were perforated with holes like a sieve; morbid exhalations consequently take place into the substance of the tissues, between the tunics of the intestines, into the parenchyma of the lungs, on the surface of the mucous membranes, and even into the serous cavities. The proposition, therefore, of Dieffenbach to employ defibrinized blood, in cases in which transfusion is determined upon, is altogether inadmissible.

"If, instead of removing at once all the fibrine from the blood of an animal, we remove it by small portions, we find that these repeated subtractions induce local lesions, of which there is no mistaking the origin." Lect. 13.—"You may even remove a considerable quantity of fibrine without producing any evil consequence, provided you are cautious about abstracting a small portion only at a time, and allowing some time to elapse between each operation."—Lect. 16.

When the fibrine was removed by small and repeated subtractions, M. Magendie found that the amount contained in the blood, instead of diminishing, actually augmented in *volume*. He caused three bleedings to be practised at equal intervals, on a large dog, of twelve, ten and eight ounces. On each occasion the blood was beaten up, filtered through a linen cloth, and then immediately reinjected into the veins of the animal. The fibrine of the first bleeding was whitish, supple and elastic, in fact normal in its character: that of the second was softer, more spongy, and more voluminous, though the quantity furnishing it was less; these characters were still more distinctly marked in the fibrine of the third bleeding; it was more voluminous than in the previous instance, its fracture instead of being clean, showed irregular filaments, proving that the force of cohesion, by which it resisted traction, is unequally shared by its fibres. When the two are weighed comparatively, it is found that the healthy fibrine, though inferior in point of mass, weighs considerably more than the other. Among the chemical characters of the two substances there is one which renders it impossible to confound the fibrine of secondary formation with the normal species,—it is that if the former be submitted to a temperature of 60° centigrade in a sand bath, it liquifies just like so much albumen. To this substance M. Magendie has given the name of *pseudo-fibrine*. The animal on which this experiment was made, was fed entirely on feculæ which contain no fibrine. Hence it is possible, by gradually defibrinizing the blood, to alter its normal properties without, of necessity, depriving it of the power of coagulating."—Lect. 13.

This pseudo-fibrine does not prevent the blood from becoming extravasated into the substance of the tissues.—Lect. 19.

One of the defibrinized animals, which a few days previously laboured under all the symptoms of purulent ophthalmia, with commencing opacity of the cornea—the condition of the different organic functions being indicative of a typhoid state of the system—was put on a nourishing diet in sufficient quantity, and he was found to have undergone a complete metamorphosis. He was previously in a complete state of prostration: he was now become gay and full of life. His eyes were quite cured, the cornea had recovered its natural polish and transparency, except in one or two spots, indicating the site of the ulceration that had commenced to form.—Lect. 20.

Lesions of exactly the same description as those caused by the abstraction of the fibrine are produced, according to the experiments of the lecturer, by the injection into the veins of certain substances, as the sub-carbonate of soda, which destroy the coagulability of the blood. The animal is immediately affected with dyspnœa, frequent pulse, bloody stools, exhalation of blood from the pituitary membrane, and complete debility, terminating shortly in death. On dissecting the body, the blood is found to be completely fluid; the lungs scarcely collapse on the chest being opened, their surface is of a reddish-brown, instead of being rosy; their tissue is firmer and contains less air than in the natural state. The cavities of the heart are contracted and contain no coagula, but some grumous masses. The lining membrane of the ventricles and arteries is deeply coloured with imbibed blood. In the cavities of the pleuræ are effusions of sanguinolent fluid, resembling in anatomical characters the affections termed hemorrhagic pleurisy. The condition of the peritoneum is the same; in its cavity is found an effusion of the same kind which reddens the surface of the abdominal viscera. The kidney and liver are engorged

with blood; the spleen has lost its normal structure, being converted into a compact, homogeneous mass, resembling a sponge that has been long macerated in water. The serous coat of the intestines is raised in different points by small ecchymoses of variable size, sometimes solitary and sometimes communicating with each other, appearing in some spots to penetrate into the cavity of the peritoneum, rather by imbibition than rupture. The mucous coat presents reddish cylinders, interlacing in every variety of mode, caused by the dilated and obstructed vessels. Large follicular patches are spread over the whole surface of the bowels, and in every direction blood is exhaled through the coats of the vessels. Even the corpora cavernosa penis are swollen with a notable quantity of fluid blood.—Lect. 18.

In general, however, according to M. Magendie, the blood when liquefied by the sub-carbonate of soda, affects especially the lungs, leaving the various abdominal organs intact.—Lect. 13.

A drachm of œnanthic ether mixed with an equal quantity of distilled water was injected into the veins of a dog. The animal immediately fell down with every symptom of drunkenness. He remained motionless, became comatose, his respiration grew loud and stertorous, and he died in forty-five minutes. On incising, the next day, the muscles of the trunk, a quantity of fluid blood issued from the vessels—it seemed as if no clots had been formed in their interior. The lungs presented most of the signs of engorgement, among others, augmented weight and density; but there was no true hepatization—a new proof, according to M. Magendie, that this latter condition is connected with the coagulating property the blood possesses while living. The heart and great vessels were filled with blood, more viscid than that of animals killed by sub-carbonate of soda, though of the same appearance to the eye. The internal surface of the vessels was studded with brownish patches, produced by the imbibition of some of the elements and the colouring matter of the blood—no fibrinous clots were to be found. The liver and spleen were evidently enlarged; when cut, a quantity of black viscous blood flowed in greater abundance than usual. The same was the case with the kidneys and other parenchymatous viscera. The external surface of the stomach and intestines was streaked with reddish lines, radiating in various directions, and forming a net-work by their interlacement—these were the capillaries distended with fluid blood. There were no extensive patches of extravasation, for death was so rapid that the liquids had no time to penetrate the walls of the intestines by imbibition.

"As the sudden introduction of a little œnanthic ether into the veins of an animal," observes the lecturer, "destroys the coagulability of its blood, it is by no means impossible but that the prolonged abuse of wine may, in the end, entail similar modifications in the physical properties of that fluid."—Lect. 4.

Some blood, immediately on its removal from an artery was mixed with putrid water, and not the least trace of coagulation occurred;—another portion of blood was mixed with pure water, and the whole became speedily solid. Hence the prevention of coagulation in the blood mixed with the putrid water was evidently to be ascribed to the latter—probably to the hydro-sulphate of ammonia formed in the process of putrefaction. A few drops of putrid water were then injected into the veins of an animal, and death almost immediately occurred. On cutting through the integuments, liquid blood flowed from the incision; the muscles presented a remarkable punctated red colouration, such as is often met with in the brain, and is

caused by a vast number of small petechiæ formed of extravasated blood; the lung was scarcely at all diseased; the mucous coat of the intestine was raised by a deposition of blood in the subjacent cellular tissue; on its surface were large patches of albumen and mucus, "the whole forming a very excellent case of gastro-enteritis for the disciples of a certain school."—Lect. 13. This experiment, according to M. Magendie, explains in some measure the pathology of disease resulting from the introduction into the system of putrid miasmata.—Lect. 13—14.

While the sub-carbonate of soda injected into the veins acts specially on the lungs, these organs are scarcely affected by the injection of putrid water, which exercises all its deleterious influence on the intestinal canal. Lect. 14.

In another instance of death from the injection of putrid water into the veins, the lungs presented no apparent lesion; the heart was flabby and collapsed; the blood in the right cavities liquid, black, and viscous; the left ventricle perfectly empty; the intestines were black coloured, *inflamed*, according to the current phrase; transudation had taken place on their internal surface, partly constituted of the colouring matter of the blood; which appearance, according to the lecturer, fully accounted for the bloody stools of the dysenteric flux, under which the animal laboured.—Lect. 15.

After noticing the usual opinion of the non-coagulability of the blood in scurvy, M. Magendie remarks (Lect. 16.)

"A short time since M. James inserted an essay in the '*Gazette Médicale*' on this subject, wherein he developed, with considerable talent, the ideas I broached respecting it last year, and supported the opinion that the alkaline character of the blood might be the cause of the non-coagulability of that fluid, as well as the symptoms of scurvy. But though this essay is a meritorious production, it furnishes decisive proof how very necessary it is to draw general conclusions with deliberate caution, for the inference drawn in it is quite fallacious. Here is the blood of an individual affected with scurvy sent me by M. Leuret, physician to Bicêtre. The gums of the patient are, I am informed, considerably swollen, his teeth are quite loose, the surface is covered with large petechiæ, and some parts of the body are œdematous: nevertheless, the blood presents a firm and consistent clot; the colouring matter alone is visibly altered in constitution, being of a brownish red colour."

"Among the medicated drinks employed in fevers," remarks the lecturer, "sulphuric acid is one of those most frequently prescribed. I was consequently desirous of ascertaining the nature of its direct action on the blood. With this view I mixed a *few drops* of sulphuric acid with a larger quantity of water, proportionally, than that entering into the composition of the 'sulphuric lemonade' of our hospitals, and injected a few centilitres of the liquid into the jugular vein of a dog. Death followed almost instantaneously, and the blood was found to be non-coagulable."

By experiments with sulphuric acid mixed with blood out of the body, M. Magendie found that one drop of the acid was sufficient to deprive five centilitres of blood of its power of coagulating; subsequently he added fifteen drops of the acid to thirty centilitres of water, and poured four drops of this solution into twenty centilitres more of water, and found that even this liquified the blood, and altered the constitution of the globules, although it did not coagulate the albumen.—Lect. 17.

The substances which M. Magendie found to prevent the coagulation of the blood are the sulphuric, hydrochloric, nitric, tartaric, oxalic, citric, lactic, acetic, tannic, hydrocyanic, boracic, arsenious acids; soda, potassa, lime, ammonia, with their carbonates; nitrates of potassa, lime, and strych-

nia, sulphate of morphia, narcotine; the chloride of gold; ioduret of iron; putrid water, decoction of digitalis.—Lect. 17.

What, according to the lecturer, gives its chief importance to the study of the coagulation of the blood is, that, as has been shown to demonstration, the loss of this property by the blood, no matter under what circumstances it occurs, is followed by death. His investigations, also, leave, he conceives, no doubt that the substances which liquefy the blood out of the body, act in the same manner on that fluid when introduced into the living tubes of our organs.—Lect. 13.

The following substances M. Magendie has found to promote the coagulation of the blood:—water, sugared water, the hydroclorates of soda, potassa and ammonia; the serum of ascites, boracic acid, borax, nitrate of silver and of bismuth, hydrosulphate of potassa and ammonia, the Seltzer, Vichy and Seidlitz waters, ioduret of potassium, tartar emetic, sulphate of magnesia, alcohol, cyanuret of gold and of mercury, the acetate and hydrochlorate of morphia, mannite.—Lect. 17.

Ether mixed with pure water, dissolves the globules, but does not prevent the formation of a coagulum. *Claret*, mingled with a small proportion of blood did not coagulate it, but allowed of the transudation of a small quantity of serum. *Claret and water* caused an agglomeration of the albumen at the upper, while a small clot formed at the lower part of the vessel. *Beer and cider* precipitated the albumen, and prevented the formation of a coagulum.

The various *neutral tartrates* added to the blood do not appear to impede coagulation; on the contrary, the larger the proportion in which they enter into the mixture, the more solid the resulting coagulum.

Soluble cream of tartar,—tartrate of potass rendered soluble by the addition of a certain quantity of borax,—mixed with blood gave the whole a deep olive colour and threw down a slight precipitate of albumen. A drachm dissolved in twenty centilitres of water, introduced into the veins of an animal, caused instant death. On dissection the muscles were found completely discoloured,—the lung was partly engorged, partly hepatized,—in the first instance the blood is imbibed into the tissue of the organ,—in the latter, it is in addition solidified. The cause of death was, in this instance, the sudden coagulation of the blood; the promptitude with which the fatal result occurred explains, according to the lecturer, the healthy condition of the intestines.—Lect. 17.

The reason why this and other substances which cause such fatal effects when introduced into the veins, may be ingested into the stomach in considerable quantities without injury, according to M. Magendie, is that in the latter case they are so slowly absorbed that a small quantity of them only can ever be said to be in contact with the blood—they only pass through it, to be promptly thrown off by some one of the emunctories, and, as it were, have no time to act.—Lect. 19.

In a mixture of equal volumes of blood and normal pus, the colour of the former was merely changed, while a perfect clot was formed. In a mixture of artificial serous pus, water and blood, the colouring matter floated on top, and was partly dissolved in the serosity,—the globules were few in number, and there is no coagulum.—Lect. 19.

Hydrochlorate of soda when mixed with blood, is remarkable like sugar, for not dissolving the globules, but it promotes their separation from the coagulable matter or fibrine; it renders the clot, also, of a very beauti-

ful arterial red, even in its centre where it cannot come in contact with the air.—Lect. 11.

Seven grains of *oxalic acid* were introduced into the jugular vein of a dog. The animal was seized with dyspnœa soon after; his condition grew worse every hour, and he died next morning. On dissection, the lungs were found not to collapse when the thorax was opened; the pulmonary artery being cut into, fluid and brownish blood flowed out, and the cells of the lungs were distended with fluid blood.—Lect. 15.

A microscopical examination showed that all the acids experimented with, gave rise in the blood to very nearly the same phenomena. Not a trace of fibrine was discoverable in the various solutions. The blood acted on by the acetic acid, was almost transparent; some nebulous flocculi and very delicate filaments only were observable here and there. In that acted on by the lactic acid, some delicate particles in suspension were detected, and globules of a particular sort, forming small masses by their union; the colouring matter and fibrine had totally disappeared. In that acted on by the hydrochloric acid, some bodies were discovered of unusual form, held in suspension, some of them rectilinear, others curved in the shape of an S, others in that of a crescent; still some traces of globules were to be seen, larger than those of normal blood, and hence probably in a state of disorganization. The solution of the blood mixed with tartaric acid was the least perfect; here and there were to be seen large coloured globules of various dimensions; close to these, others of the same form, but colourless; next some much smaller, and finally, irregular corpuscula. The colourless globules, the lecturer remarks, resembled the large white globules which are to be seen in blood immediately after it has been drawn. "Now," he adds, "no corpuscula of this kind are to be seen in blood in circulation, and it would consequently be very curious if tartaric acid possessed the property of rendering these globules apparent. All the other substances tried had entirely liquefied the blood; no trace either of globules or fibrine was perceptible in the mixtures made with them."—Lect. 15.

M. Magendie submitted the blood to the action of the various gases. The *oxygen* was partly absorbed; the coagulum was of a scarlet red colour, firm and perfectly coagulated. *Nitrogen* did not prevent solidification; was not absorbed; the clot presented no vermillion tint at the points of contact with the gas. *Carbonic acid* did not prevent solidification; the clot was tolerably firm, of a brownish red colour, approaching to black; the serum was reddish, and lay above the clot. *Oxide of carbon* was not absorbed. A firm coagulum formed of a brilliant surface above bathed in deep red serum. *Quadro-carburet of hydrogen*, allowed of the formation of a firm clot of a violet colour; the serosity perfectly limpid and distinct from the clot. *Cyanogen* was more abundantly absorbed than any other, M. Magendie supposes, in consequence of the alkalinity of the blood, it having a strong tendency to combine with alkalies. *Chlorine* completely decomposed the blood, rendering it black.

By a microscopical examination of the blood subjected to the gases, M. Magendie discovered in the blood submitted to *oxygen*, a mass of globules of the ordinary shape, remarkable for the distinctness of their central point; besides, there were to be seen a great quantity of other globules, resulting from the union of smaller globules, and very closely resembling pus; while some of these last described bodies separated from each other

and floated in the serosity. To examine them more distinctly, he mixed them with serum, which, to his astonishment, dissolved them entirely. These lenticular bodies, which are evidently of a distinct species, and had never been previously observed, either by himself, or so far as he is aware, by other physiologists, appear to the lecturer to have been developed under the influence of the oxygen.

In some blood mixed with *hydro-sulphuric acid gas*, he found some globules which were unchanged, and an innumerable quantity of globular points, half white, half black, as though a line of intersection had separated an ordinary globule into two parts. These globules appeared to execute movements, to oscillate in various directions, with extreme rapidity, describing curved, straight, or irregular lines, as is done by the microscopic animalcules termed *monads*.

Nitrogen alters in no wise the conformation of the globules, or of the agglomerations of minuter globular bodies, already mentioned in the case of oxygen gas. The action of the two gases, M. Magendie remarks, would appear to be very analogous.

The lecturer tested by experiment the influence of temperature on the coagulation of the blood; he submitted it to a temperature of 14°, and to that of 50° to 55° Réaumur; from which, and other experiments, he concludes, that neither *cold, heat, rest nor motion* prevent the occurrence of coagulation, excepting only when blood is received from an artery into the body of a syringe which has been heated to 30° Réaumur; in this case so long as the liquid in the latter receives the impulsion communicated by the heart, it does not form into a mass.

M. Magendie ascertained that blood which coagulated under a temperature of 14° Réaumur, does not again become fluid as has been asserted, when its temperature was again gradually raised.—Lect. 14.

He considers the fibrine of the blood to be different from that of the muscles. In proof that they are not identical, in addition to the absence of resemblance in their physical properties, he mentions that compared in respect of their alimentary qualities, they differ widely. He has demonstrated, he remarks, by direct experiments, that the fibrine of the blood is but slightly nutritive, whereas that of muscle is extremely so.—Lecture 7.

An old pupil of M. Magendie, M. Denis, has made some very curious researches on the chemical composition of the blood; among other important facts, it would appear from his labours, that the fibrine is nothing more than albumen combined with the different salts.—Lect. 4.

When the blood is removed from the body, it separates, as is well known, into two parts, the one solid composed of the fibrine and the red globules, the other fluid, or *the serum*. The latter is the liquor sanguinis deprived of its fibrine by the spontaneous coagulation of the latter; it contains water, albumen, chloride of potassium and sodium, lactate of soda, carbon, phosphorus and animal matter. In the blood of a healthy and robust male, the serum may be estimated as forming a fifth or a fourth of the whole. In women and children, it constitutes one-third of the mass. But these proportions, according to the lecturer, vary according to age, temperament, and species of nourishment of the individual, as well as a variety of other circumstances. Successive bleedings, closely following each other augment the proportion of serosity, and induce various disorders, and finally death.—Lect. 7.

It is extremely difficult, at first view to determine, in any given case, the relative proportion of the serum and the clot, as under certain circumstances the fibrine, while in the act of solidifying, retains a considerable share of serosity within its areolæ. In such cases, it is necessary to cut the mass into slices, which causes the serosity to ooze out on all sides. If the clot be soft, however quickly coagulation may have taken place, it it is almost certain that it contains serum interposed between its meshes. Lect. 9.

M. Magendie remarks, that in every case of serious disease he has met with since commencing his researches on the blood, the clot and serum have invariably presented some anomaly in respect of their relative volume. In his opinion, a superabundance of serum in the blood is a positive contraindication to bloodletting, and he conceives that this fact will, sooner or later, be admitted as a fundamental position in the treatment of disease.—*Ibid.*

The serum of the human blood being injected into the veins of an animal, gives rise to the most serious consequences. In one animal, it caused retraction of the limbs, and considerable derangement of the cerebral functions; in a previous experiment, it caused puriform effusion into the joints. The injection of the serum of a dog, was followed by an affection, attended by most acute pains resembling those of rheumatism, with remarkable acceleration of the pulsation of the heart.—*Ibid.*

The dog in whose veins ten ounces of human serum was injected, died forty-eight hours after the operation; the blood was rendered so fluid, that on opening a vein in the neck after death, and hanging up the animal by his hind legs, the greater part of the contents of the vessels trickled away. M. Magendie thinks it probable that the fluidity of the blood is to be explained by the alkaline character of the serum introduced. The lesions of the pulmonary organs were not very strongly marked. The most remarkable morbid condition was that of the cephalo-rachidian fluid; it was in the first place reddish in colour, as though the globules of the blood were dissolved in it; in the next it had formed into a sort of coagulum, and seemed of a totally different nature from the normal liquid.

"I am inclined to think," observes the lecturer, "that the albumen of the serum transuded through the capillaries of the pia mater, and so became extravasated into the sub-arachnoid cavity. The injection of simple water into the veins, does not determine this gelatineform appearance of the extravasated liquid."

In some previous experiments of M. Magendie, he produced various disorders of the nervous system, as general trembling, involuntary movements, signs of coma, and various forms of tetanus, from the injection of water in the veins; and on dissection detected disorganised blood under the inner lamina of the arachnoid.

The animal of whose autopsy we are now speaking, presented signs of lesion of the nervous system, and the lecturer considers that its state of prostration, and the frequent contraction of its limbs were induced by the morbid condition produced in the cephalo-rachidian fluid; the animal's right eye, also, was seriously affected, and had already commenced to suppurate. There was marked disease of the intestinal canal indicated by patches in a commencing state of ulceration, with tumefaction and engorgement of the mucous tissue caused by the effusion of blood, and all

the phenomena, which, remarks the lecturer, we see manifested in the diseases known by the name of typhoid affections.—Lect. 10.

M. Magendie conceives that an excess of serosity in the blood, however produced, augments the tendency to inflammation. In repeating the experiments of Brodie on the ligature of the ductus choledochus, he remarks—

"The animals on which I practised the operation, died, without exception, of peritonitis. With a view of preventing this disagreeable result, I practised a copious bleeding before the experiment, fancying, in conformity with the notions then prevalent, that I should thereby infallibly put a stop to the development of inflammation; the inflammation, nevertheless, appeared with even still greater intensity than before. Subsequently, I injected water in the room of the blood withdrawn, but in every instance, peritonitis supervened with greater violence than before, and proved rapidly fatal. At the present time, when more correct notions of pathology have replaced those of former days, it appears to me that the more the blood abounds in serosity, the more probable it becomes that the consecutive exhalation of the serous membranes will be abundant; and hence, that to use the orthodox language, inflammation will be more violently developed."

"I do not hesitate to assert," adds the lecturer, "that the anti-inflammatory bleeding, ordinarily practised before capital operations, may frequently, according to the constitution of the individual undergoing them, help to determine the serious accidents observed to follow those operations."—Lect. 9.

The blood of a patient labouring under *albuminous nephritis*, examined under a microscope, produced, in addition to the ordinary globules, a multitude of little globules, "or rather corpuscula," without any determinate shape;

"These I might almost affirm were formed of albumen. I then proceeded to a slight chemical examination of the serum, being anxious to learn if the serum of this blood would, as in ordinary cases, coagulate by the action of heat. It did form into a mass, but when coagulated, it resembled pus much more strongly than healthy serum; besides this, an albuminous liquid oozed from the clotted mass, which I was unable to succeed in coagulating. The solidified part, too, was less firm and coherent than usual, allowing a glass rod to sink into it simply from its weight. This examination, imperfect though it be, seems to indicate the reality of a morbid alteration of the albumen of the serum, in the disease under consideration."—Lect. 10.

In the animal in whose veins human serum was injected, the urine became albuminous, and on a few drops of nitric acid being added to it, and to a portion of urine from a patient labouring under albuminous nephritis, they both became white and turbid, and presented whitish flocculi of perfectly analogous character in both instances. The colour of the two fluids was not exactly the same, probably depending, as the lecturer supposes, on the variety of the salts that one of them may have contained. The urine of an animal who died after twenty days' total abstinence from solid and liquid nourishment, appeared to be albuminous, as nitric acid threw down a very abundant precipitate in it.

"These comparisons of similar affections, produced by different causes, are very important," remarks M. Magendie; "for if, in the present case, the privation of food induced the disease, it is clear we ought to avoid bleeding, putting on low diet, or otherwise weakening any individual affected with it. I do not, however," he adds, "lay any great stress on this point for the present, as the fancied resemblance may not be a real one."

In the animal on whom the injection of serum was practised, neither the kidney nor any other part of the genito-urinary apparatus presented the least trace of the abnormal granulations described by Dr. Bright.—Lect. 11.

M. Magendie when subsequently experimenting on the urine of defibrinated animals, found that an immense amount of flocculi, of albuminous appearance, were thrown down, but on examining these analytically, he found that they were formed of nitrate of urea, which was also the case with the flocculent precipitate in the urine of the animal who died from forced abstinence.—Lect. 12.

One of the constituents of the serum is *albumen*. Like fibrine it exists in the blood in a state of solution, and like it, too, is capable of forming into a mass, and participates in effecting the nutrition and growth of our organs. According to the lecturer it would appear that, in common with the fibrine, the albumen assists in rendering the blood adapted to pass through the capillary vessels, and that when the blood loses its albuminous ingredient in any way, it becomes extravasated, and is imbibed by the surrounding tissues. Unlike the fibrine, the albumen never undergoes spontaneous coagulation, but it may be rendered solid by heat, alcohol, acids and certain saline substances. The albumen of the serum of the blood, is not identical with that contained in the white of eggs. Thus a few drops of potass being added to the white of an egg, there forms instantly a transparent, solid and elastic jelly, resembling isinglass, composed of albuminate of potassa; added to the serosity secreted by the peritoneum in a case of peritonitis, there takes place a scarcely visible precipitation. Acetic acid forms with the serum of the blood, and the white of an egg nearly similar coagula; when these are exposed to a moderate degree of heat, that from the egg undergoes no change, while that from the serum liquefies, and again becomes solid when allowed to cool. Ammonia, with the white of eggs, gives rise to a transparent gelatinous precipitate, which, when heated, coagulates firmly, presenting the appearance of a vesicular spongy matter; the albumen of serum exhibits none of these characters. Ether only faintly affects the albumen of the serum, but converts that of eggs into a white mass, in the same manner as heat.—Lect. 21.

M. Magendie injected the albumen of eggs into the veins of an animal, and found that after twenty minutes it became changed in its nature, and transformed into albumen, identical in character with that in the blood with which it was mixed. Immediately after the injection of the whites of four eggs strained through a cloth, the animal was seized with vomiting; during the succeeding forty-eight hours, he remained in a tolerably tranquil state, when the whites of two more eggs were introduced; there was no return of vomiting; the whites of two eggs additional being again injected on the following day, the animal died almost immediately. On dissection the blood was found to be in a fluid state. The cells of the lungs were filled with black blood; the left lung was infiltrated in a very remarkable degree; the lungs were tuberculated. The follicles of the intestines were much developed, forming eminences beneath the tunics that invest them. —Lect. 22.

The white of an egg added to blood out of the body, does not prevent the coagulation of the latter, but what is very curious, it is converted into a similar substance with the serum of the blood.—*Ibid.*

M. Magendie repeated the injection of the albumen of eggs into the veins of an animal. The whites of five eggs diluted with five times their

volume of water were introduced into the jugular vein of a dog; the latter experienced no inconvenience whatever from the operation; nor did the blood, which coagulated perfectly well, and contained but a small proportional quantity of serum, indicate by any unusual viscidity, nor by the action of the two chief re-agents, give any evidence of the albumen that had been added to it. Less than a drachm, of a very viscid solution of albumen injected into the carotid of the same animal, produced the most violent struggles, followed by almost immediate death. A solution of dextrine, of about the same viscosity and consistence as albumen, whether injected into the veins or arteries of a dog, produced no apparent effects.—*Ibid.*

"There are," remarks the lecturer, "a considerable number of fluids in the economy which contain albumen, and even in larger proportion than the serum. The ovarian vesicles, for example, are filled with a viscid humour, which is yellowish and limpid, and resembles the albumen of eggs." "On the other hand, certain liquids, which appear almost wholly composed of albumen, really contain scarcely any of that principle. Such, for example, is the fluid which fills the cavities and invests the exterior of the brain and spinal marrow. Still we may state in general terms, with truth, that a certain quantity of the substance in question will be found in all the great accumulations of fluid produced in the economy, whether their existence be the result of a physiological or pathological process. Cysts almost always contain some, and in tumours of that species developed in the ovaries, a considerable proportion is always found. Again, ulcerated surfaces have been known to throw off albumen. I have under my care two young persons affected with lumbar abscess; suppuration has ceased for some time, but has been replaced by the discharge of a viscid matter, which M. Pelouze has ascertained to be formed of pure albumen. There are cases, too, in which the urine contains notable quantities of this principle."—Lecture 22.

M. Magendie injected a small quantity of bile into the pleura of a dog, and a violent inflammation immediately declared itself. The membrane, or rather the subjacent vascular rete, became extremely red, while its sensibility was greatly augmented.

"The contact of the bile," observes the lecturer, "caused the minute vessels to contract, and so oppose the course of the blood in the interior—the consequent stoppage of the circulation caused the extravasation of serum. We can, by injecting any irritating substance into the serous cavities, determine similar effusions; this is even one of the best ways of procuring fibrine dissolved in the serum, and separated from the globules."—"Once out of the vessels, the fibrine promptly forms into masses, and may be easily obtained in the shape of filaments and lamellæ.

"Hence, it suffices to obliterate the capillaries in order to produce effusion either of the blood in substance, or of some of its elements. If you wish to observe the phenomenon still more distinctly, you have only to perform the experiment on larger animals, such as the horse. Give this animal an artificial pleurisy, and quarts of fluid will be exhaled on the surface of the pleura; the fluid will subsequently allow the fibrine it holds in suspension to separate from it, in determinate forms, referrible to a common type of organisation. The serosity is of a citron or fawn colour, and is subject to great variety in the proportion it bears to the false membranes formed along with it."

"It is a curious fact, that the irritating fluid is completely absorbed before any morbid exhalations take place on the surface to which it has been applied. There was no bitter taste in the fluid effused, in consequence of the introduction of bile into the pleura."

"When the fibrine passes from the fluid to the solid state in the living animal, it always carries with it, in the process of organisation, a certain quantity

of albumen. This is especially remarkable in the formation of false membranes, and, indeed, in a variety of other instances. Examine, for example, the liquid exhaled on the surface of cicatrices, which subsequently, by its solidification, forms the pellicle that covers them—treat it by the appropriate tests, and you will see that it is composed of albumen and fibrine."—"In other cases, the albumen is found in an isolated condition. If you leave some pus at rest, its component elements soon separate; an albuminous fluid goes to the top, and a sediment, more or less solid, is found at the bottom. Purulent matter is, in truth, formed of globules and albumen, mixed with different salts of the blood." "I submitted some pus to the action of a pretty strong heat, and a flocculent precipitation of albumen took place, but the globules neither disappeared nor underwent any modification; whence the necessary conclusion that they cannot be composed of albumen."—Lect. 22.

According to M. Magendie, the *globules* of the blood, when examined under the microscope, are seen to consist of a sort of investment, with a nucleus in the centre. But both investment and nucleus disappear by washing, and the water employed becomes red coloured, like the serum in some diseases. From which he concludes that, in the mammalia, these corpuscula are not formed of an investing substance and nucleus, analogous to those of fishes. Hence, he remarks, sanguineous globules are divisible into two classes: those with, and those without, a nucleus. The former belong to reptiles and fishes, the latter to mammalia and birds. The globules of other animals have not been sufficiently examined, in this point of view, to admit of any opinion being formed respecting them. The above opinion, in regard to the structure of the globules, is at variance with that maintained by some physiologists; the lecturer gives it as the result of his experiments.—Lect. 4.

"It has been asserted," says M. Magendie, "that the size of the globules varies considerably in the human subject, and that, under certain circumstances, their diameter does not exceed the 100th, the 120th, or even of the 150th part of a millemètre. Their magnitude does vary; but I feel almost certain that their diameter never exceeds an eightieth of a millemètre. Now this point of limitation to the size of the globules is extremely remarkable, from the relation it bears to the diameter of the vessels in which they are destined to move."—Lect. 4.

According to the lecturer, there are various kinds of globules found in the same blood. In that of the human subject, for example, there are some that exist constantly, and others that are not persistent.

"Among the former are to be ranged the red globules, of different forms and dimensions; among the second, we find the large white globules, of which the uses are equally unknown, though they deserve investigation at the hands of observers, because they form some of the normal constituents of the blood. Along with these, are found other globules, infinitely smaller than the red and white ones, which it has been fancied belong to the lymph or chyle. So far, however, this opinion respecting their nature is merely conjectural."

"It would appear, also, that, in the course of certain diseases, globules of particular structure and appearance are developed."—Lect. 23.

The point which strikes the observer most strongly after the first glance, the lecturer remarks, is, that in the centre of the red globules is seen a black or white point, according to its degree of nearness to the focus of the instrument, and the quantity of the light that falls on it; so that, sometimes one would fancy them perforated in the centre, while, in other cases, a sort of nucleus, distinct from the mass of the globules, is very perceptible. These appearances M. Magendie believes to be deceptive, and not real. According

to some physiologists, the centre of the globules contains a solid nucleus in the mammalia, while, in the opinion of others and that of the lecturer, it is more depressed and thinner in the point than elsewhere.—Lect. 23.

M. Magendie, by the micrometer, ascertained, that the ordinary size of the red globules of human blood varies from the one hundredth and tenth to the one hundredth and twentieth part of a millemètre.

"The term globule," he remarks, "is inappropriately applied to these bodies, for their form is not spherical but lenticular. What proves this is, that when they roll under the microscope, they turn their edge to the eye of the observer. This edge generally measures, in point of thickness, the fifth or sixth part of their superficial extent; seen in this manner, the globule appears thicker than at its middle, which part has the appearance of being slightly depressed, and, as it were, excavated; this is, however, the case only with the globules of mammiferous animals, for those of others, such as reptiles and fishes, present a real swelling in their centre."—*Ibid.*

Even with a magnifying power of eighteen hundred times, M. Magendie has not been able to satisfy himself of the presence of either an investment or central nucleus in the globules of human blood. He admits that it is possible they may be provided with an investment which ruptures.

"Observers are, indeed, generally of opinion that they are surrounded with a very delicate pellicle; and this idea receives some support from the fact, that, in the globules of dead subjects, there is a sort of puckering visible, such as is presented by membranes of extreme thinness, when they begin to dry, for instance, the outer skin of onions."—*Ibid.*

The lecturer has detected the same appearance in the globules of a vigorous and healthy individual, after they stood for a certain time in a vessel.

"This fact seems to indicate that the globules are enveloped in a sort of membrane, and that this membrane is soluble in water, the acids, the alkalies, and a variety of other fluids, consequently they must possess some peculiar properties which enable them to retain their form; otherwise, as the blood contains water and various salts, the globules must of necessity be dissolved."

For the first two or three days, after being drawn from the body, according to M. Magendie, no very evident change occurs in the globules—their surface becomes mottled with minute spots; subsequently, they become the seat of movements of totality, resembling those of infusoria; it is this which has probably made various authors fancy that the globules were, in truth, so many animalcules.

"These movements, which are exceedingly evident, resemble what are called in physiology *vibratile motions*, and are observable in various organs, especially in the mucous membranes of birds, and of the human subject. In the latter, the borders only of the membrane are subject to these vibrations, whereas the centre even of the globule manifests the phenomenon distinctly."

M. Magendie has distinctly perceived small *vibrions* on the globules, moving on their surface, penetrating into their substance, and issuing from it by the edges.

"Finally, the globule diminishes in size, and gradually disappears; it appears to be devoured by these infusoria, which has not been mentioned, the lecturer believes, by any other person. Some globules present a multitude of these animalcules; others, a very few. Thus the blood furnished by a nasal polypus, which he excised lately, contained an innumerable quantity of them."—Lect. 23.

M. Magendie put some globules from newly drawn blood into serum containing a large proportion of vibrions, and observed that the latter "pounced on them with a sort of fury," and destroyed them totally in a very short time. He found these animalcules less active when presented to globules of rabbits' blood; the globules from the blood of a bird they turned over, but almost immediately abandoned. They seemed to regard with even stronger repugnance the globules of frogs' blood; they rushed in troops towards them, but almost immediately quitted them.

In the globules of reptiles, one of the diameters, the lecturer observes, is evidently more elongated than the other—they present a very distinct spot in their centre, and, when they turn on their axis, a prominence is visible on their edge.

"When shaken in water, they dissolve, except the central part, which is white when it has been well washed, and retains the elliptic form of the original globule. Besides these globules, there are other spherical opaque corpuscula to be seen, without any nucleus."—*Ibid.*

"In birds, the globules are elliptic, but have no nucleus." "The globules of reptiles have a mean size of from the forty-fifth to the seventy-fifth part of a millemètre; they are, consequently, much larger than those of mammiferous animals and birds."—Lect. 23.

It has been supposed, by respectable physiologists, that the coagulum of the blood is formed by the adhesion of the globules to each other.—When we examine the clot, it appears quite clear that the globules are present, adhering to the filaments of fibrine, and appearing to form an integral part of it; if, however, the clot be well washed, the globules are carried away, or dissolved according to the nature of the liquid employed, and the consolidated fibrine with all its true characters alone remains. Every fact, indeed, proves that the globules have no agency whatever in the spontaneous coagulation of the blood, and that this depends entirely on the presence of fibrine in its normal state.

"All my experiments," remarks the lecturer, "go to prove that, strictly speaking, we might understand the possibility of life in blood composed of serum and fibrine only. As to the globules, nothing positive is known respecting their uses, and for my part, I know no other kind of utility they possess, beyond that of facilitating the microscopical investigation of the blood. Nevertheless, as they do exist, consequently, there must be some reason for, and usefulness in, their presence in the midst of the vital fluid."—Lect. 12.

The various oscillations, and rising and descending motions observed in the globules of the blood both within and out of its proper vessels, and which have given origin to the idea entertained by some, that the globules are endowed with the power of spontaneous motion, M. Magendie has demonstrated to be mere mechanical or optical phenomena. He has shown, in regard to the agitation which occurs in a drop of blood, dissolved in alkaline or sugared water, that the same phenomenon, precisely, occurs when particles of colouring matter are suspended in distilled water.—Lect. 14.

"With respect to the relations of the globules to each other: those that are circular, when placed in serum, adhere to each other, and form flexible piles of variable length. It is not long since it was believed that these globules, thus heaped and piled one on the other, formed the basis of, or rather actually constituted, muscular fibre; but besides that muscular fibre has not the appearance of globules piled on each other, it is a matter of demonstration that it contains none of them. The modes of agglomeration of these little bodies are so numerous and various, that it is useless to attempt their description."

"The elliptical globules of birds do not form piles or chaplets. they become mutually attached, but this attachment takes place by all the points of their surface, and especially by the extremities of their greater diameter; they thus constitute masses of a particular aspect. They are then seen to adhere to each other by a single point, instead of being superimposed by their whole surface, as in other instances. On mingling circular and elliptic globules together, it was found that those of the same form adhered to each other. It would appear from this, that they are under the influence of the electrical phenomena of attraction and repulsion.

"As for their structure, it is certain that the globules of reptiles contain a central nucleus, surrounded with a lighter coloured areola. In birds, on the contrary, the middle part of the globule is occupied by a nebulous matter, having the appearance of a nucleus."—Lect. 23.

By the experiments of M. Magendie, it was clearly shown that some substances act energetically on the globules, while others have no effect on them. Among the former, are the acids. The hydrosulphuric acid not only destroys their colour, but their whole substance. On the other hand, the bicarbonate of soda tinges them of a scarlet colour. Tannic acid changes their colour to a pale pink.—*Ibid.*

The lecturer injected two pounds and a half of globules, taken from three dogs, into the veins of another dog. The animal died in a few days in a state of extreme weakness; his gait was staggering, like that of defibrinised animals. On dissection, the lungs were found altered in appearance, and covered with petechiæ, as in defibrinised animals, but the blood had coagulated slightly in the vessels; the mucous membrane of the intestines was healthy.

Fifteen centilitres of turkeys' blood was injected into the veins of a dog; the animal died next morning. The lung presented peculiar arborisations, and was engorged with fluid blood. On examining the blood under the microscope, no traces were dicovered of the elliptic globules that had been injected. "It would appear that they had undergone some modification in their passage through the capillary vessels of the animals; and this, if I may be allowed to hazard a supposition," says M. Magendie, "would lead us to believe that the configuration of the minute vessels of mammalia and birds differs."

The blood of twelve or fifteen frogs, the globules of which are much larger than those of the mammalia, and have a central nucleus formed of an element distinct from the colouring matter, was injected into the veins of a young dog—no bad consequences resulted, and not a single globule of the elliptic form could be detected in his blood.

It appears to the lecturer to be an indubitable fact, that the proportion of globules and serum undergoes an increase or diminution under particular circumstances; thus, after a certain number of bleedings, the blood is rich in serosity, but poorly supplied with globules. In the class of affections called anemic, the colouring matter of the blood is to a certain extent lost.

Independently of the red globules, there are, according to the lecturer, others of a different kind in the blood, dissimilar to these in size, conformation, and colour; they are known as the *white globules*. These have neither central spots nor prominence, but a small part of lighter colour than the rest, which gives to them a peculiar appearance; they are flat and lenticular, like the red globules, and often stick to the glass on which they are laid for examination, while those of the coloured species float about, and oscillate hither and thither continually; water, acetic acid and ammonia

dissolve the red, but do not affect the while globules. M. Magendie has never observed these bodies in the blood in circulation. It has been supposed, that they are nothing more than minute fragments of fibrine, which adhere to the object glass in consequence of their coagulation. M. Letellier affirms, that, if red globules be left in a vessel, white ones may be seen to gravitate to the bottom. The lecturer has never seen bodies of this kind in the blood of reptiles, birds, or fishes.

M. Magendie merely alludes to a species of globules distinguished by their mammillated, raspberry-like look. Some suppose this appearance to depend on an optical delusion, caused by the iridescent appearances produced when two plates of glass are not in immediate contact. There is still another kind of globules, of much smaller size, of which the lecturer discovered a large quantity in a patient affected with albuminous urine; they appear to belong, more particularly, to the lymph and chyle.—Lecture 23.

We have now presented a tolerably full exposition of the principal facts in relation to the physiology of the blood comprised in the lectures of M. Magendie. All of these facts are highly interesting and important, while, in many instances, they are established by experiments and observations of a novel and ingenious, but at the same time highly satisfactory, character. It was our intention, had we been able, with justice to our author as well as to our readers, to condense our analysis within a smaller compass, to have noticed some of the pathological views thrown out in the course of these lectures: more especially those in reference to the phenomena generally ascribed to inflammation, which M. Magendie considers to be nothing more than the local expression of the effects resulting from either an alteration in the qualities of the blood, or a want of harmony between the diameter of the capillaries, and the volume of the molecules of the blood, giving rise to an obstruction, to a greater or less extent, of the circulation.

Ingenious and plausible as we are willing to confess his exposition of many of the pathological conditions of the organs and tissues to be, we cannot, however, admit that in all cases they are legitimate deductions from even those facts upon which he has based them, while, also, they run counter to all our experience in relation to the curative powers of most of the ordinary therapeutical agents. They are, nevertheless, worthy of a cautious examination, and cannot fail to have, at least, one beneficial effect: that of directing the attention of physicians to the state of the blood in disease, and to the influence of our remedies in modifying its several abnormal conditions: which latter cannot fail, in our opinion, to keep up and extend morbid action, if they be not, in many cases, its immediate cause. The influence of the blood, and of the changes which it unquestionably undergoes in its physical properties and composition, have been too much overlooked in all our pathological investigations. D. F. C.